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HABITAT DEVELOPMENT AT EIGHT CORPS OF ENGINEERS SITES:
FEASIBILITY AND ASSESSMENT(U) ARMY ENGINEER WATERWAYS
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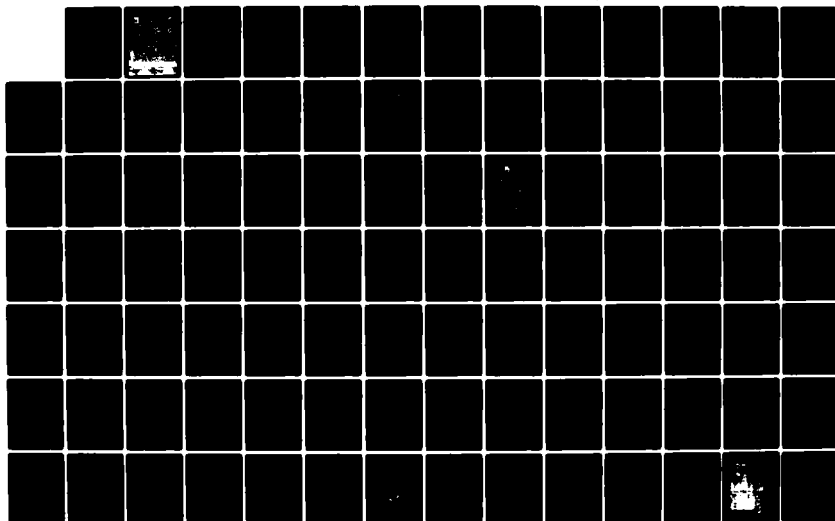
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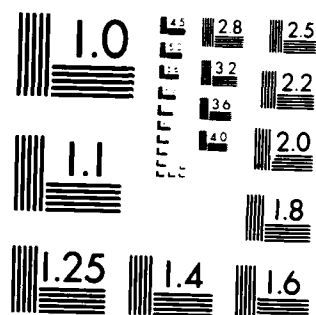
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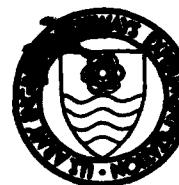


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DREDGING OPERATIONS TECHNICAL SUPPORT



MISCELLANEOUS PAPER D-82-1

HABITAT DEVELOPMENT AT EIGHT CORPS OF ENGINEER SITES FEASIBILITY AND ASSESSMENT

Mark A. Canfield, Editor

Environmental Laboratory

U.S. Army Engineer Waterways Experiment Station
P.O. Box 631, Vicksburg, Miss. 39180

October 1982

Final Report

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Eight sites located in Corps of Engineers Districts (Baltimore, Detroit, Fort Worth, New Orleans, Los Angeles, Philadelphia, and Savannah) were ex- amined upon District requests to the Dredging Operations Technical Support Program at the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Habitat development feasibility and assessment were studied at estu- arine sites in the Santa Ana River, Calif.; Trinity River, Tex.; Brunswick (Continued)		

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20. ABSTRACT (Continued).

Harbor, Ga.; Smith Island, Md.; Tangier Island, Va.; and the Delaware River, Pa. Marsh restoration and habitat development were studied at freshwater sites on Bayou Dourcheat, La., and at Point Mouillee, Lake Erie, Mich. Development of salt marshes, fresh marshes and ponds, bottomland hardwoods, furbearer habitat, waterfowl habitat, and sea-bird habitat and island creation and management are discussed in detail for appropriate sites.

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PREFACE

This report was prepared as part of the Dredging Operations Technical Support (DOTS) Program, which was established in part to ensure the transfer of the technology developed by the Dredged Material Research Program (DMRP) and to support the Corps' dredging and environmental regulatory programs. The DOTS Program is sponsored by the Office, Chief of Engineers, through the Dredging Division of the Water Resources Support Center. The program is assigned to the Environmental Laboratory (EL) of the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss.

During the period of 1978 to July 1980, the DOTS Program provided major assistance to Corps Districts in the use of dredged material for habitat development. Reports were furnished in each instance and are compiled here for ready reference for application in similar situations. The reports are in the form in which they were sent to the requesting District without editorial revision.

The eight District-assistance reports contained herein were written by the following EL scientists and engineers:

Mary C. Landin	Parts II, IV, V, and VII
Charles J. Newling	Part III
Landin and Newling	Part VI
Landin and Mary K. Vincent	Part VIII
Landin, Thomas R. Patin, and L. Jean Hunt	Part IX

Ms. Landin also wrote Part I and compiled and edited the entire report.

Work progressed under the general supervision of Dr. H. K. Smith, Wetlands and Terrestrial Habitat Group (WTHG); Mr. Hollis H. Allen, Revegetation and Habitat Development Team Leader (WTHG); Mr. Charles C. Calhoun, Jr., Manager, and Mr. Thomas R. Patin of DOTS; and Dr. John Harrison, Chief, EL.

Director of WES during the preparation of this report was COL Nelson P. Conover, CE. Technical Director was Mr. F. R. Brown.

This report should be cited as follows:

Landin, M. C., ed. 1982. "Habitat Development at Eight Corps of Engineers Sites: Feasibility and Assessment," Miscellaneous Paper D-82-1, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
acres	0.405	hectares
acres	4046.856	square metres
cubic yards	0.7645549	cubic metres
cups	0.0002366	cubic metres
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
feet	0.3048	metres
gallons per minute	3.785412	cubic decimetres per minute
inches	2.54	centimetres
miles (U. S. statute)	1.609344	kilometres
pounds (mass)	0.4535924	kilograms
pounds (mass) per acre	0.000112	kilograms per square metre
square miles	2.589988	square kilometres
square yards	0.8361274	square metres
tablespoons	14.784	millilitres
yards	0.9144	metres

* To obtain Celsius (C) readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use $K = (5/9)(F - 32) + 273.15$.

HABITAT DEVELOPMENT AT EIGHT CORPS OF ENGINEERS SITES:
FEASIBILITY AND ASSESSMENT

PART I: INTRODUCTION

1. During the conduct of the Dredged Material Research Program (DMRP), it became apparent that, for the results to have maximum benefits, it would be necessary to continue the technology transfer activities after the program was completed. There was also a continuing requirement to conduct research to support the Corps' dynamically evolving environmental regulatory program. To meet these and other needs, the Dredging Operations Technical Support (DOTS) Program was established by the Office, Chief of Engineers (OCE), in April 1978, with responsibility assigned to the U. S. Army Engineer Waterways Experiment Station (WES), Environmental Laboratory (EL), Vicksburg, Miss.

2. Since the establishment of DOTS, the scientists and engineers in the EL have responded to numerous requests for assistance from the various Corps District and Division Offices and other Federal and State agencies through its technology transfer/advisory role. Eight major requests requiring detailed analyses of habitat development feasibility and assessment at various dredged material disposal sites around the United States have been completed by the Wetlands and Terrestrial Habitat Group (WTHG) of EL through August 1980, and several other major requests are currently under assessment.

3. The eight completed major District requests involve a wide range of habitat development problems and situations. Each is addressed as a separate part of this report. Parts II through IX have been furnished to the various requesting Districts in the form of assistance reports. The reports presented in this text are:

- a. "Marsh restoration and habitat development using dredged material substrates at Pointe Mouillee State Wildlife Area in Lake Erie, Michigan." This assessment involved freshwater marsh, upland, and island development under the unique wind, climatic, and water level fluctuations

of Lake Erie. It included over 4000 acres* of habitat that was lost to the lake from erosion over a period of 40 years. Habitat development will primarily be for waterfowl and seabird use, and for hunter, fisheries, and other non-consumptive recreational benefits. This request was received from the Detroit District.

- b. "Feasibility report on a Santa Ana River marsh restoration and habitat development project." This study considered salt marsh and coastal dune restoration and land use changes and protection. Expansion of habitat for the endangered California least tern was also a project consideration. This request came from the Los Angeles District.
- c. "Brunswick, Georgia, harbor deepening project: habitat development and marsh valuation." This project concerned using dredged material deposits for salt marsh and upland/island habitat development within the Brunswick River estuary. Part of the request concerned establishing values of marshes in general and salt marshes in particular. The request was received from the Savannah District.
- d. "Restoration of wetlands habitat on Gifford-Hill Mining Company lands in northwestern Louisiana." Destruction by unpermitted mining of a cypress swamp and a bottomland hardwood forest area prompted restoration attempts in order to obtain a permit for mining work. This freshwater site was adjacent to a large bayou and fed into a major watershed. The request was received from the New Orleans District.
- e. "Dredged material uses and disposal alternatives for the Trinity River Basin project, Texas." The Trinity River channelization project to allow ocean shipping to Dallas-Fort Worth requires disposal of 750,000,000 cu yd of dredged material. Habitat development uses for some of this material were addressed. The request came from the Fort Worth District.
- f. "Potential habitat development sites in the Delaware River." This site is a fresh to brackish tidal estuary that requires frequent dredging. Habitat development alternatives and sites for use of the dredged material were addressed, as well as wildlife uses in that estuary system. The request came from the Philadelphia District.
- g. "Shoreline stabilization and marsh development west of Tangier Island, Chesapeake Bay, Virginia." The extreme erosion problem at Tangier Island was addressed along with recommendations for island stabilization and salt marsh

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 10.

restoration of the historic island. The request was received from the Baltimore District.

- h. "Preliminary feasibility evaluation of dredged material disposal, habitat development, and erosion control at Smith Island, Chesapeake Bay, Maryland." The need for disposal sites coupled with the need for island stabilization made this salt marsh and island development study necessary. The request was received from the Baltimore District.

4. Other habitat development requests for DOTS assistance have come from the Office, Chief of Engineers, and CE Districts and Divisions: Charleston, Jacksonville, Mobile, Savannah, Wilmington, New England, New York, Chicago, Rock Island, Detroit, St. Paul, Alaska, Seattle, Galveston, Little Rock, Sacramento, Lower Mississippi Valley, Memphis, New Orleans, St. Louis, Vicksburg, Louisville, Tulsa, and Nashville. Requests for habitat development or assessment work have also come from the National Audubon Society; the U. S. Fish and Wildlife Service; Mississippi Chemical Corporation; North Carolina Sea Grant researchers at the University of North Carolina; the States of Michigan, Georgia, and Maine; and Gifford-Hill Mining Company.

PART II: MARSH RESTORATION AND HABITAT DEVELOPMENT USING DREDGED
MATERIAL SUBSTRATES AT POINTE MOUILLEE STATE
WILDLIFE AREA IN LAKE ERIE, MICHIGAN

by

M. C. Landin

Background

5. The Pointe Mouillee State Game Area on Lake Erie's northwestern shore in Michigan was at one time one of the finest freshwater marshes in the Great Lakes. It had great historical significance and has been used as a wildlife area since the first settlers arrived on Lake Erie shores (Barbour 1940, Michigan Department of Natural Resources (MDNR) 1979). Over a period of approximately 40 years, the barrier beach which protected it has eroded and been overtopped, resulting in severe wave erosion of the Pointe Mouillee marsh. This was due primarily to an increase in lake levels. The other major factor that caused the destruction of the Pointe Mouillee marsh was construction of dams and reservoirs on the Huron River (MDNR 1979). This essentially stopped almost all sediment sources which replenished the marsh area. Over 4000 acres of prime marsh, wetlands, and barrier beach were flooded and a large part is now open water (Figure 1).

6. The diked disposal area presently being constructed by Detroit District (DD) is located upon the remnants of the old barrier beach and is lakeward of the drowned mouth of the Huron River (Figure 2). The dike is scheduled to be built in four years; it will take at least 10-12 years to fill the inside of the dike to an upland elevation through maintenance dredging (DD 1974, MDNR 1979).

7. This disposal area is being constructed by the DD with full approval of the MDNR. It originally had several broad objectives:

- a. To allow the DD to dispose of large quantities of dredged material from the Detroit River and the shipping lanes entering Lake Erie.

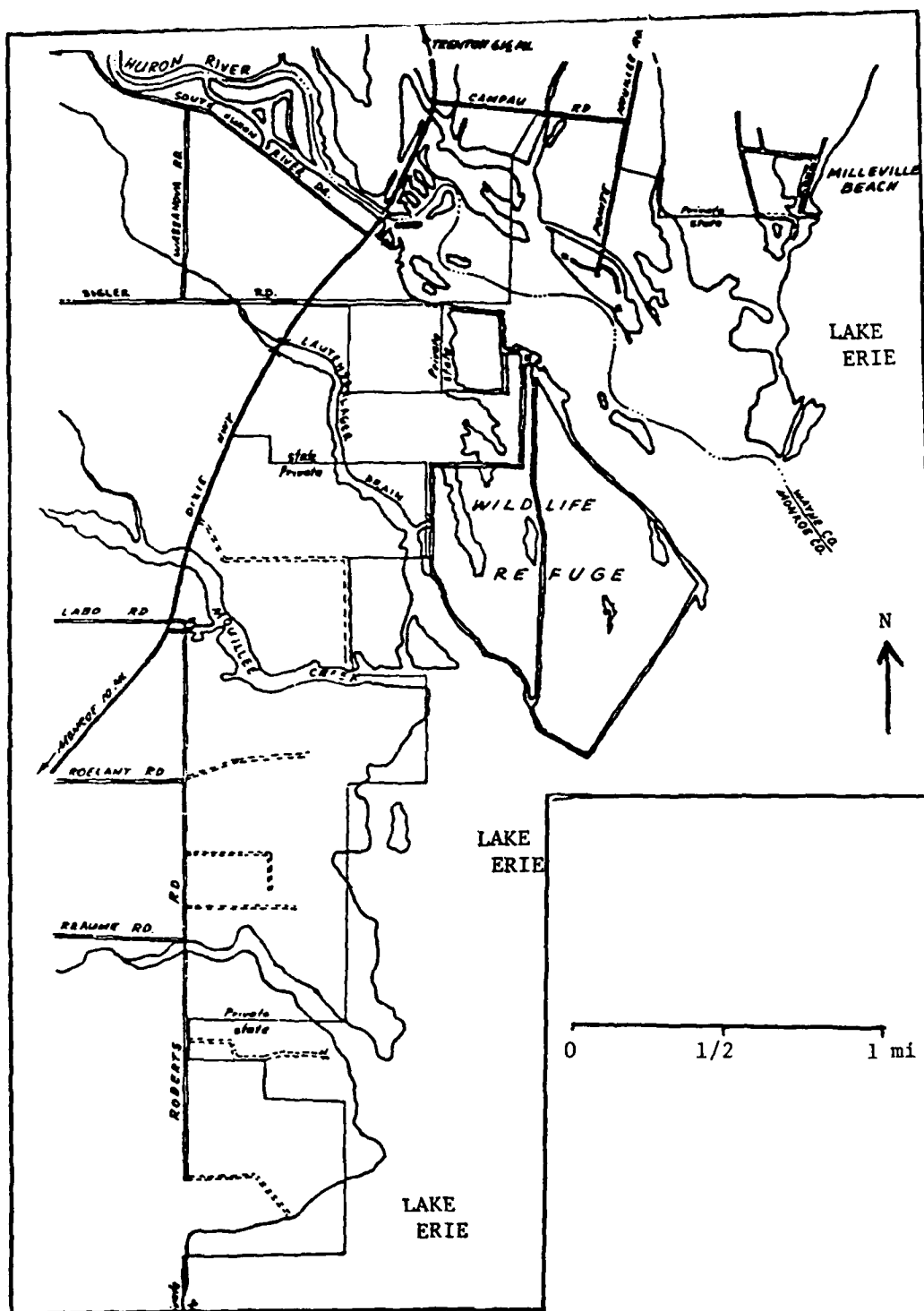


Figure 1. The Pointe Mouillee area based on a 1973 aerial photograph. Over 4000 acres of marsh (in 1930) is now open water. The diked area was established by MDNR in an effort to maintain some marsh habitat. This dike was eroding badly in 1979 and has been reinforced by the Corps' Pointe Mouillee diked disposal area contractor

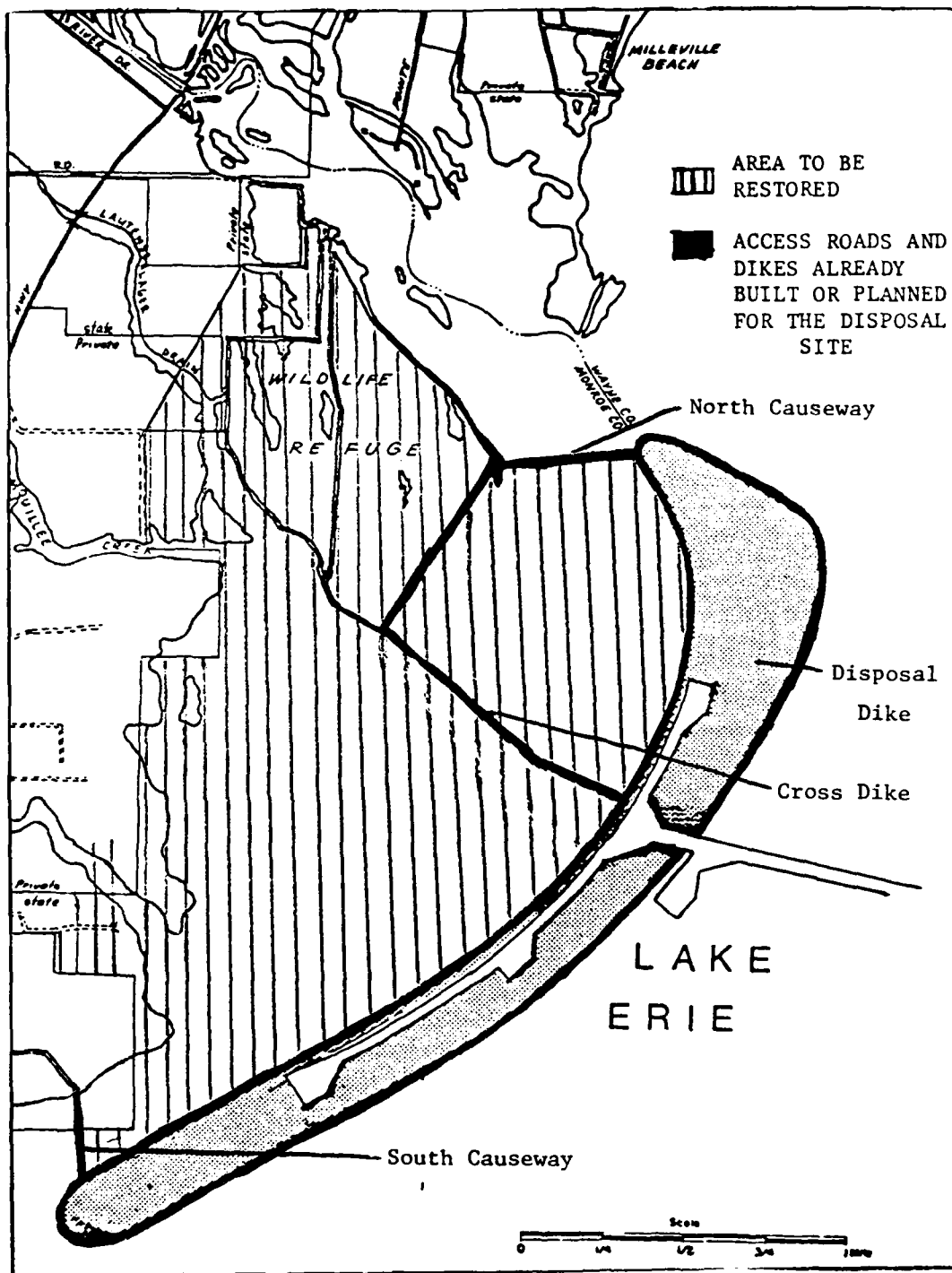


Figure 2. The Pointe Mouillee area with a sketch of the diked disposal area under construction, the marsh area to be restored, the proposed cross dike, and the constructed south and north access roads from the mainland

- b. To allow natural sedimentation to occur behind the dike so that the marsh that had once been at Pointe Mouillee could be naturally redeveloped.
- c. To use the interior section of the dike for wildlife habitat as it became filled with dredged material.
- d. To protect via the riprapped dike the Pointe Mouillee State Game Area.

8. Over time, the original plan has changed to include improved technology in habitat development regarding more rapid development of the marsh. The MDNR requested of the DD that necessary dredging for the dike footing be used to fill the to-be-restored area, and that the Corps help them develop a feasible marsh development plan. The DD assessed the situation, which represented a change in goals b and c above, and determined that a supplemental Environmental Impact Statement (EIS) was necessary before these changes could be implemented.

9. Original major objectives of Pointe Mouillee have now been changed to include, in addition to the original objectives a, c, and d (omitting b):

- a. To place and manipulate dredged material behind the diked disposal area to hasten achievement of a marsh elevation.
- b. To build a cross dike for better control of water levels on the management area and to provide for habitat diversity.
- c. To build a permanent road giving access to the dike from the north as well as from the south.
- d. To construct at least four waterfowl and waterbird nesting islands inside the developed marsh.
- e. To develop a restoration plan for the Pointe Mouillee marsh.
- f. To actively and intensively manage both the marsh and the disposal area for maximum wildlife use while allowing reasonable public access for recreational purposes.

10. DOTS was asked by the DD to assess five major items to be included in the supplemental EIS and to aid in decisions regarding permit issuance for construction activities at the site, which are identified below:

- a. The general feasibility of the proposed work in marsh reestablishment and evaluation of the MDNR restoration plan (as presented in the draft EIS and in this report as Appendix B).*
- b. The kinds and ranges of anticipated water quality effects.
- c. The potential for botulism or other major adverse effects during and after construction.
- d. The extent of public access compatible with anticipated wildlife activity.
- e. Any additional concerns which can be identified and addressed.

11. This report is presented in two major sections in order to address the requests from the DD: (a) assessment and evaluation of the five items in paragraph 11 and (b) habitat development. Habitat development, because of its extensiveness and the need for assessment of the MDNR plan, will be addressed separately. In addition, alternative plans for habitat development will be discussed for the marsh area, the diked disposal area, and the open water areas.

Feasibility, Water Quality, Environmental Impacts, and Public Use

Feasibility of marsh reestablishment

12. Any assessment of feasibility involves three major factors: engineering, biology, and economy. There are other factors such as socio-economic pressures from local and regional citizens, interest groups such as sportsmen and farmers, and anticipated land uses which also play a role in determining feasibility.

13. Engineering. After examination of data presented in the USAEDD (1974) EIS on soils, talking with Holloway Construction Company (HCC) engineers, and taking into consideration the contractors' need for sites to dispose of additional material (MDNR 1979), it appears

* A draft Master Plan has been written and published by MDNR in 1980 for general information and is available from MDNR, Lansing, Mich.

to be reasonable that a marsh of suitable soils, quality, and stability can be built on the Pointe Mouillee State Game Area. The foundation soils in the old marsh behind the diked disposal area consist of clays with an average 2-4 ft of peat over the bed clay. While the peat will not provide a firm foundation, the clay will serve as good footing for placement of dredged material at an elevation conducive to a marsh interspersed with upland nesting islands. The clay will also serve as good dike material to hold the interior-placed peaty material to be used to construct nesting islands and the cross dike as planned.

14. Engineering specifications for habitat development, especially in marshes, can be very exacting and are critical to success (Environmental Laboratory 1978a, Hunt et al. 1978, Palermo 1977, and Smith 1976). It is exceptionally difficult to rework wet clay material, and it is suggested that the final elevation be obtained by frequently moving the discharge pipe. Mounding for island development is achieved by continuous discharge at one station (Environmental Laboratory 1978a). With clay material, mounding can only be achieved by mounding of clay balls in the slurry. These engineering specifications can be addressed by the engineers at WES if the DD feels this is necessary.

15. For marsh development purposes, unless the dredged material is carefully placed by the contractor so that no shaping or sloping of material is needed to provide the proper elevations, it may become necessary to manipulate the material with heavy equipment to reach the proper elevations. In a clay/peat soil, unless the site can be thoroughly dewatered, this can be extremely difficult if not impossible. Therefore, care should be taken by the contractor to move the disposal pipes often so that marsh elevations are only achieved where they are desired. The exceptions to this are at the four specified sites where MDNR wants to place islands for nesting and at the cross dike. Inability of the contractor to do this will make marsh reestablishment more difficult to achieve.

16. Biology. Biological feasibility addresses several considerations: plant, wildlife, and artificial propagation vs. natural colonization of habitat. Regardless of whether the plant community can

be established by either artificial or natural means, it is important to wildlife since all wildlife depends upon the plants for food and cover as they use the marsh. Undoubtedly, a marsh plant community will be established in the area if the correct elevations are achieved and/or permanent water control structures are built. Freshwater marshes are very quickly colonized by plant propagules from sources such as seeds, sprigs, and root mats (Environmental Laboratory 1978a). The area in which the dredged material is being placed has supported a marsh for centuries; the dredged material is of similar texture to the original marsh. If the correct elevation is achieved as planned, there is no apparent biological reason to believe that a marsh will not establish here.

17. The wildlife that will use the area should not be adversely impacted by the reestablishment of a marsh; rather, wildlife that will normally use a freshwater marsh in the Great Lakes region will be benefited by the development of new habitat. The old Pointe Mouillee marsh was heavily used by waterfowl, numerous songbirds, waterbirds, and raptors for migration, breeding, and feeding. The present open water habitat, while it is still used by some species of waterfowl and waterbirds, is of reduced value for wildlife compared to the old marsh habitat (MDNR 1979). Fisheries could be generally impacted by the reduction of open water which presently serves as a new nursery area for Lake Erie fish species. While some protected open water will remain, the amount will be reduced by emergent marsh and nesting islands, as well as by cross dikes and access roads. However, from an overall biological consideration, marsh reestablishment at Pointe Mouillee is feasible and should enhance the area for both wildlife and fisheries.

18. Economy. The reestablishment of the Pointe Mouillee marsh with its planned access roads will also increase hunting, fishing, bird watching, boating, and other forms of water and wetlands recreation. The marsh historically has been heavily used for waterfowl hunting. Due to the small numbers of game birds, the high water levels, and intensified demand on decreasing habitat, MDNR first had to restrict use by limiting hunter numbers, then encouraged furbearer

trapping rather than hunting, and finally had to practically eliminate all sportsmen recreation from the area because of the reduction in usable areas. The return of this habitat should greatly increase the ability of the area to support hunter populations, as well as make the area usable to other recreationalists. Considerable funds are expended each year by hunters, trappers, fishermen, small boaters, bird watchers, and nature lovers. The marsh should once again help the economy of the local area.

19. Potential impacts of fisheries use of the area should not affect the feasibility of the project, as a 1:1 ratio of open water to marsh is the management goal of MDNR inside the marsh area (MDNR 1979).

20. Cost-feasibility of the marsh reestablishment project is assumed to be acceptable to the DD and the MDNR; according to the DD, the two agencies have agreements for financing all construction, marsh development, monitoring, and management efforts.

Water quality and impacts

21. The subject of water quality in the marsh is of significance to marsh reestablishment. Considerations include marsh plant uptake of contaminants, potential contamination sources and their impacts on marshes, and changes in wildlife populations because of contaminants. Lee (Appendix C) addressed some potential overall problems regarding water quality, and the reader is referred to this document.

22. Studies during the DMRP have shown that while marsh plants will take up certain heavy metals from anaerobic substrates, the uptake is usually limited to roots and tubers in large amounts (Lee et al. 1976 and 1978). Unless wildlife eat the roots and tubers, they will usually not have been greatly affected by feeding in a contaminated disposal site. One species of wildlife that frequents the Pointe Mouillee marsh is the Canada goose;* it has been reported to grub up roots and rhizomes of marsh plants and feed on them. Certain plants

* Common and scientific names of all flora and fauna listed in this report are presented in Appendix A in alphabetical order.

such as soft bulrush, cattails, and soft rush either have very thick root mats or nonpalatable roots which prevent them from being fed upon, thereby making these species good possibilities for use in a freshwater contaminated area.

23. There is no practical way to prevent use of a contaminated disposal area by avian wildlife. The Toledo Diked Disposal Area at Toledo in Lake Erie is a case in point. The U. S. Fish and Wildlife Service personnel point out that the numerous waterbirds which feed within the dike are feeding in contaminated waters. The DD had the area fenced and padlocked but this has not prevented avian use. No measurements of the impacts of feeding in these waters by waterbirds have been made, but no visual effects have been noted, and the birds fly from as far as 20 km away to feed there because of the scarcity of good feeding habitat nearer their nesting colonies (Soots and Landin 1978).

24. Two ways to prevent feeding and other uses of a contaminated site by waterbirds is by dewatering the area and keeping it that way between disposals or by putting up aerial barriers of some sort to prevent their flying into the site; neither of these is practical or economically feasible. Nesting use of such an area is acceptable as long as the use is by species such as gulls and terns which are usually open water feeders (away from the site).

25. Considering the texture of the dredged material to be deposited within the marsh area behind the dike, contamination should not be a problem. Clay particles tend to hold metals and other contaminants tied up as long as the soils remain waterlogged (Dr. Charles R. Lee, 1979, personal communication). The chance of considerable uptake by marsh plants in anaerobic conditions is relatively small. This in turn should not have any major impacts on wildlife populations that would use the Pointe Mouillee marsh.

26. Other problems, or discussion of details concerning chemistry of uptake, soil/contaminant interactions, and potential for biomagnification should be addressed to Dr. Charles R. Lee, the author of several WES technical reports concerning contaminants.

Potential for botulism
and other adverse impacts

27. Botulism can be a problem in northern marshes, especially to waterfowl as they feed in a shallow standing (or stagnant) water area. The methods for preventing botulism die-off from occurring on management areas are well known; the MDNR has been dealing with this problem effectively for years. The usual method is simply to prevent water from stagnating by providing inlets and outlets in the ponded area. The contractors at Pointe Mouillee have adequately provided for this by installing a series of to-be-gated large culverts in both the south and north access roads leading to the diked disposal area (Figure 2) that may be opened in summer months to provide circulation. In addition, if the cross dike is constructed, eleven gated culverts will be installed in it as well as ensure flow of water from the Huron River through the marsh area. This flow will probably be greatly reduced from normal river flow and would be, in effect, a slowly moving backwater area of the river system, but it should be adequate to prevent stagnation of the marsh ponded areas. As for problems in the diverted streams (Mouillee Creek, Bad Creek, and Lautenschlager Drain) in the area, stagnation of the water in summer months can be prevented by providing a gentle slope for the stream to follow or to make the channel at such a depth as to be as low as average-to-low lake levels as is already planned by the MDNR.

28. Providing for a slow flow of water through the marsh behind the diked disposal area will also help keep mosquito problems in the marsh at a minimum. Mosquitoes may be a summer problem inside the diked disposal area until it is filled to an upland elevation. The DMRP addressed this problem, and advice offered by Ezell (1978) will be helpful while this site is being filled and until it is dewatered.

29. Another adverse impact that would occur from marsh reestablishment at Pointe Mouillee is the reduction in fishery nursery areas as discussed in paragraphs 18-20. It was pointed out by the MDNR (1979) that in general, while pond-stream fish species are now present, the only lake fish now using the Pointe Mouillee area for spawning are

noncommercial species not generally of very much economic importance in the Great Lakes except for cannery or pet food operations. In addition, the MDNR is planning stretches of open water that can be used for fishery nurseries within the marsh.

30. The influx of recreationalists into the newly reestablished marsh could have a negative impact. There is the potential for extremely heavy use because of the large population of people living in the Detroit/Toledo area. The metropolitan area has over three million people who are within a driving distance of one hour or less from Pointe Mouillee. Should this become a problem, limits may have to be placed on numbers of hunters, fishermen, etc., who are allowed on the area at any given time. The MDNR is already considering limiting access to the disposal area except at designated times. This limited access would allow isolation for breeding and brook rearing by marsh animals and protect the marsh from human overuse. The concept of keeping the diked disposal area as isolated as possible should be given serious consideration to achieve target wildlife populations, especially until the site is filled. Limited access could be provided during the hunting season, but restricted in likely breeding areas during the spring and summer.

31. This isolation concept is not entirely compatible with the MDNR's mission of providing a game area for hunting and fishing as well as other outdoor recreation for Michigan's citizens. Adjustments may have to be made according to wildlife needs on a seasonal basis in order to accomodate a maximum number of people while still providing quality habitat useful to Michigan's wildlife.

Public use

32. Too much human use of a wildlife area may reduce its overall value. It is impossible at this time to develop a recommended ratio of human use and wildlife use because it cannot yet be determined how much of any given habitat (standing emergent marsh, open water pools, bare ground, nesting meadows, food plots, tree/shrub thickets) will be formed until the dredged material has actually been placed behind the dike. Much depends upon the amount of dredged material that must be

removed for the formation of the disposal dike and the elevation at which it is finally placed, as well as the amount of material remaining for marsh reestablishment after bed clay has been placed around the perimeter of the cross dike and at the nesting island locations.

33. The primary use of the new marsh will be the same as for the old marsh: waterfowl hunting. Assuming that natural meanders will form in the new marsh area as it develops and that the contour of each marsh section is uneven to allow standing water pools, there will be pools for waterfowl to use during migration so that hunting can take place. In response to the DD's request for public use limitation suggestions, a good rule of thumb is one duck blind every 200 yards along the open areas, or one each 25 acres. This has been used successfully in other states on their hunting areas where hunting pressure is very great. In addition, at least one state uses a lottery system for determining who hunts, and in some cases requires not only that steel shot be used but that each hunter can carry no more than ten shells into the hunting area.

34. Fishing will probably be the next greatest use of Pointe Mouillee. Fishing in a semi-open system such as the one being built will offer more potential than a closed pond system. Bass and other game fish are often caught in closed systems; yellow perch is the most abundant fish caught by angling in Lake Erie. Both should be caught in the semi-open system that is planned. Yellow perch in particular tend to school and provide maximum fishing wherever they happen to be feeding along the shoreline. They tend to congregate along the shoreline by day, and move out into the lake at night, which enhances fishing at Pointe Mouillee in a maximum use situation.

35. There could be considerable bird watching and nature hiking pressure at Pointe Mouillee, especially during the summer months and after the Ecological Center is built. It is during this time that breeding and brood raising will be taking place. Seabirds are already using the uncompleted dike area for loafing and would probably be nesting there if less construction activity were taking place around them. Bare ground habitat for seabirds is extremely scarce in the Great Lakes, and birds in Lake Erie are using all available man-made

sites (Scharf et al. 1978 and Landin 1979). Since colonies of seabirds and solitary nesting waterfowl, other waterbirds, and songbirds require certain amounts of isolation to successfully complete their nesting activities, it may be advisable to restrict the use of Pointe Mouillee during the breeding season except in areas reserved strictly for human use, such as fishing areas or marked nature trails. Once nesting and brood rearing are accomplished, areas could be opened up to unrestricted use. This will require a substantial enforcement effort. General rules of thumb are: keep humans away from nesting bird colonies entirely--allow no access except by very responsible researchers; restrict bird watchers to the extent that they must abide by rules such as no interference with the birds' daily activities; no disturbance during the heat of the day; no egg collecting; no watching in groups over five persons; and no catching young birds or collecting "orphan" chicks.

36. Access to humans can be easily manipulated by fences, gates, and posted signs throughout the game area. For instance, if gates with padlocks were installed on each access road as it leaves the mainland, wheeled vehicles and most boats in the diked disposal area and marsh would be prevented. If gates were installed on the dike at strategic locations, certain areas could be kept human-free while others were being used for fishing or hunting. Signing in and out of the areas at the headquarters building would help ensure use by responsible individuals and ensure that the area manager would know who was using the area. Since water access can hardly be prevented from the lake side, humans may be kept from colony sites or other protected areas by use of large posted signs easily readable from boats before they anchor. If this was not effective, stout fences could be erected on top of the dikes behind the riprap so that people would have access to the riprapped area with a walkway on top, but not to the entire top of the dike.

37. If nesting islands or nesting "wings" (extensions of the cross dike or other dikes) are constructed in the marsh area, they should have permanent posted signs on them to prevent anyone from going

onto these islands except during the fall hunting season. Nesting wings would require fencing at the point where the wing leaves the dike and extends into the marsh.

38. Trappers will heavily use the Pointe Mouillee marsh again once it is reestablished. Muskrats will once again inhabit the area; this furbearer accounts for most of the skins taken from the Pointe Mouillee marshes in past years (MDNR 1979). It may be necessary to place limitations on trapping such as assigning trapping sections each season to prevent over-trapping, especially while the muskrat population is recovering.

Additional concerns

39. There are several concerns that are site specific. Most can be prevented or corrected if and when they occur by careful and close monitoring of the marsh area and its biological and engineering features.

40. Culvert blockage. Although the MDNR plans at present to close the gates of the culverts at the north and south access roads to prevent winter ice damage to the marsh area, the gates will be manipulated during spring, summer, and fall months. It is conceivable that any one of the sections of culverts in the access roads may be blocked by logs and other drift material, aquatic plants, and/or sediment accumulation. This should be prevented so that a gentle flow throughout the marsh area can be maintained. While the numbers of culverts that have been installed seem to be adequate for flow maintenance, should any become useless, the equilibrium of the newly created marsh could be upset. Gates will be used to fluctuate water levels and to facilitate drawdown in the marsh to encourage growth of emergent marsh plants. Any blockage of gates and/or culverts could decrease the efficiency of that fluctuation and drawdown capability.

41. Replenishment of sediments. Sediments which fed the Pointe Mouillee marsh came from the Huron River. The new marsh will be fed from sediments carried through the culverts from the same river source; therefore, accumulation of sediments that will replenish eroded areas will be very slow and possibly almost nonexistent. This could be a

problem if erosion rates exceed sedimentation rates. Although no plans have considered this, there may be a possibility that additional dredged material will be needed on a reoccurring basis to maintain the marsh behind the dike. Should the marsh elevation drop below that which will support emergent marsh even with water control structures, additions of a few inches of dredged material could rebuild the marsh to the proper elevation while not being too deep to allow marsh vegetation to grow through the material. This has been proven to work on salt marshes in Georgia (Reimold et al. 1978a) but has not been tested in freshwater areas. However, I have observed several marshes which have formed or regenerated in freshwater systems after dredged material or natural sediment has been placed or occurred at a low elevation on an existing wetland site.

42. Contamination. Dredged material from new work such as that being placed behind the dike to build the marsh is not highly contaminated, according to HCC tests. However, Environmental Protection Agency standards rate sediments from both the Detroit and Huron Rivers as polluted with industrial, sewage, and/or agricultural wastes. Maintenance dredging will place these sediments within the disposal dike, which will eventually reach an upland elevation. There, plantings of upland grasses and herbs are likely to take up contaminants and reintroduce them to the food chain. Therefore, any food plot plantings should take this into consideration. The MDNR has indicated that while they plan to plant food plots and provide nesting areas on the disposal site, they do not plan to cap the material with clean soil. Soil analyses should be made to determine what contaminants are present. If they are in sufficient quantities to be harmful to wildlife, they should be capped with at least two feet of clean soil to ensure that the root systems will not reach the contaminated material. Lee (Appendix C) concurs with this opinion.

43. Any maintenance material that is needed to replenish the marsh area will also be considered contaminated. Therefore, analyses must be made to determine if such sediments can be used for marsh

development with little impact on wildlife and fisheries. Although emphasis is being placed on cleaning up rivers and harbors leading into the Great Lakes, and Lake Erie is much cleaner now than it has been in decades, the potential for severe contamination remains. If an industrial or shipping mishap should occur and large quantities of contaminants are trapped in river sediments, these contaminants could eventually become part of the Pointe Mouillee ecosystem if the sediment should be used for marsh replenishment.

44. Pest species. In an intensively managed or protected ecosystem there is a potential for certain species of wildlife to become pests; i.e., raccoons destroying nests in areas managed for wood ducks, white-tailed deer overbrowsing in areas protected for hunting, and foxes destroying nests in areas where ground-nesting birds congregate. At Pointe Mouillee, one species could present a real problem: ring-billed gulls. Throughout the Great Lakes and especially in Lake Erie, ring-billed gull populations are thriving while other seabird species are declining (Ludwig 1974, Scharf et al. 1978). This is a result of both the gulls' aggressiveness toward other colony nesting seabirds and their ability to forage for the abundant food found in human waste areas and garbage dumps as well as from their natural and traditional feeding areas.

45. Ring-billed gulls have been found by various researchers in the Great Lakes area (Blokpoel 1977 and 1978, Scharf et al. 1978) to be competing successfully and taking over already scarce nesting sites from common terns and herring gulls. The provision of bare ground habitat for seabirds at the Pointe Mouillee diked disposal site will undoubtedly cause all three species to use the area for nesting, provided they are protected from humans and severe wildlife predation. Ring-billed gulls, if they follow their usual pattern, will nest outside the colonies of herring gulls and common terns and feed on the eggs and young of the other two species at every opportunity. This will cause displacement and/or abandonment of colonies while giving the ring-billed gulls room to expand their colonies.

46. Several methods of controlling ring-billed gulls have been tried, especially by the Canadian Fish and Wildlife Service. The most promising (but disagreeable to some people) is to enter ring-billed gull colonies and periodically gather their eggs and young and destroy them. A control method such as this one should not be carried out without the advice of a qualified wildlife biologist who is in agreement that ring-billed gulls are destroying herring gull and common tern young and eggs. Care should also be taken not to be extreme and destroy too many of their young and eggs, as ring-billed gulls have found an ecological niche in the Great Lakes and have room to expand that niche. They do not, however, necessarily have to expand at the expense of the other species. Ring-billed gulls have numerous nesting colonies on island sites with herbaceous cover and tolerate this vegetation cover quite well. Herring gulls and common terns, on the other hand, much prefer very sparse to bare nesting areas in the Great Lakes. If the ring-billed gulls could be forced to nest only on islands with vegetation and leave the bare islands and sites to the other two species, the problem would be solved.

47. Management. Pointe Mouillee will respond positively to active management. With under-management of the marshes, they will begin to undergo changes that will result in a reduction of the quality and probably of marsh size. The riprapped dike system will continue to protect the marsh from erosion processes from the lake even if the marsh is not actively managed. However, erosion is not as great a danger as too much human use, subsidence of the substrate, contamination, and lack of control of water levels and the vegetation to keep the marsh at successional stages compatible with optimum use by target wildlife species.

Habitat Development

48. The Pointe Mouillee project offers more potential for habitat development in conjunction with a large dredged material disposal site than any ever undertaken in the United States and

possibly in the world. The sheer size of the marsh and disposal site (almost 8 square miles), along with the multitude of possibilities for beneficial wildlife and fisheries habitat development, productive uses, recreation potential, and marsh reestablishment, make the design of a development (restoration) plan complicated and subject to many alternative plans for the same pieces of land. The MDNR plan, which was submitted along with the draft EIS in 1979, emphasizes the difficulty of getting a complete grasp of the problem of developing dredged material and constructing dredged material dikes and island habitats. This project will include in its 4000+ acres at least 12 different kinds of general habitat (open lake water, deep protected water inside dikes, shallow protected water inside dikes, aquatic plant/shallow submergent marsh, shallow emergent marsh, standing emergent marsh, bare ground areas (islands or isolated habitat), native grass/herbaceous areas, planted nesting meadows, planted food plots, mudflats, and tree/shrub thickets) and seven different intended uses for Michigan's citizens (hunting, trapping, fishing, boating, bird watching, nature hiking, and ecology schooling at the proposed MDNR center for ecological study to be built on the site).

MDNR habitat development plan

49. The MDNR proposed to develop a plan to include all of the habitats and uses mentioned in paragraph 49. For a more complete idea of their overall concept, the reader is referred to the MDNR (1979). The MDNR's ideal marsh at Pointe Mouillee was the marsh of the 1940s and 1950s when large portions of the original marsh had already eroded away and the barrier beach had been overtopped and was gone. This marsh was approximately 50 percent shallow open water and 50 percent standing emergent marsh and was very successful from the standpoint of large numbers of waterfowl and game animals using the area. This maximized hunter and trapper use of Pointe Mouillee State Game Area. The plan the MDNR submitted to the DD is designed to recapture that lost combination of habitats, with added benefits of upland nesting and recreational areas that were never present at Pointe Mouillee historically (Figure 3).

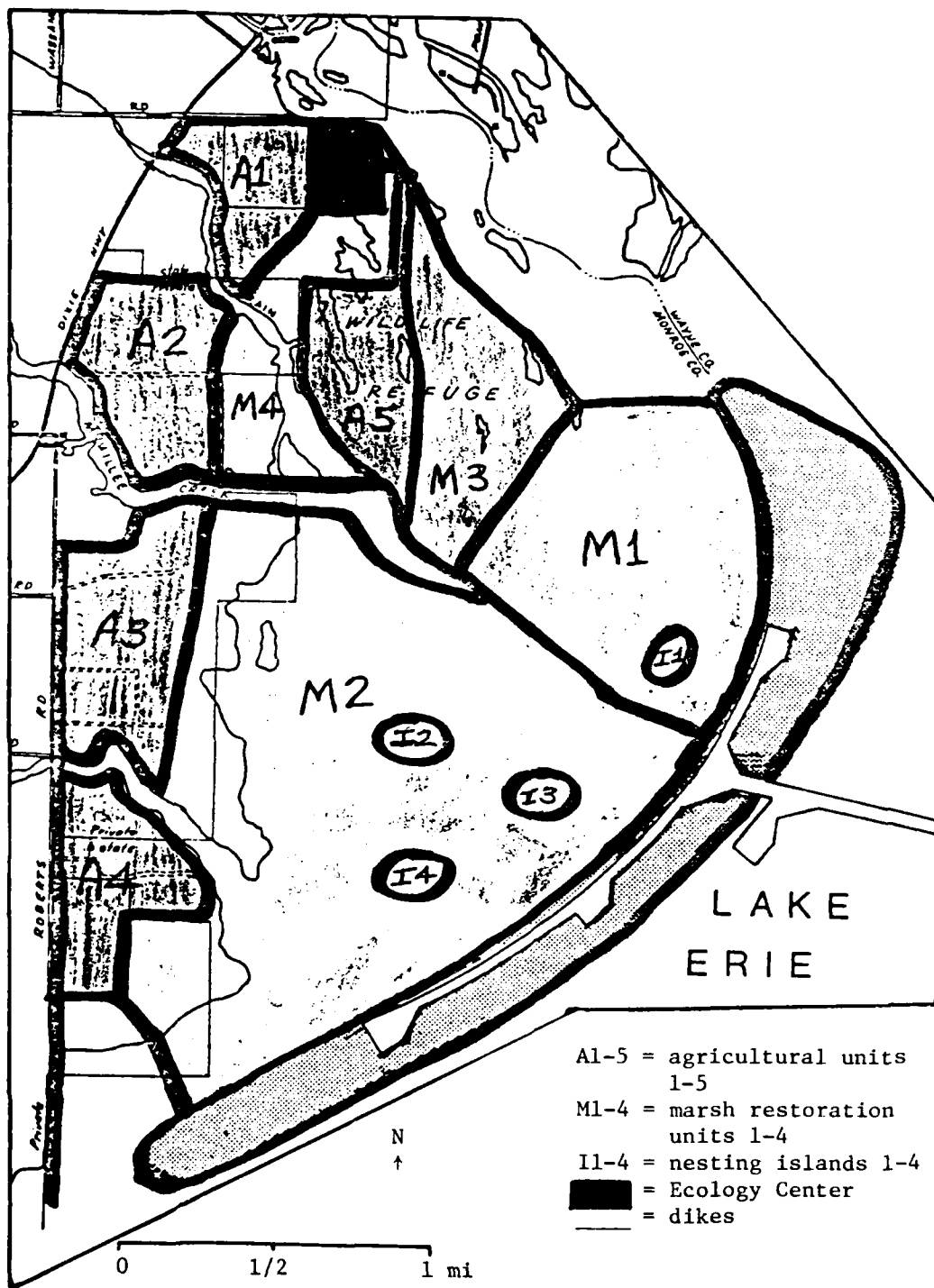


Figure 3. Sketch showing habitat development aspects and sites of the Point Mouillee State Game Area, as discussed in the MDNR plan and submitted to DD

50. The MDNR presented their plan in sections, treating the diked disposal area as one section and dividing the marshes behind the diked area into four major sections. They also include a site to be raised to an upland level that will be the location of an ecological school/classroom/museum for the educational benefit of Michigan citizens. The MDNR has plans to build several parking facilities and boat launching ramps at Pointe Mouillee at various locations and to provide nature trails and restroom facilities throughout the area. They plan to install gates at all culverts so they can control water levels at all times within the managed marsh area and to limit human use where there is danger to wildlife in any given area (during the breeding/nesting/brood raising period). The MDNR plans to plant within the marsh, emergent marsh species which will serve as food and cover for all forms of wildlife, and to plant on the diked disposal site upland grasses, food plants, and other species that will provide food and cover for upland wildlife species. They plan to provide bare ground habitat for colony nesting seabirds. They also intend, with the cooperation of local farmers, to plant five agricultural units with various food crops for wildlife, primarily waterfowl, on the fringes of the restored marsh.

51. The MDNR's plans are highly ambitious and are an indication of the seriousness in which they are approaching the restoration of this lost marsh area and the habitat development involved with this restoration. In general, the plan is sound, although the manner in which it was presented in the draft EIS (1979) submitted to the DD makes it hard to follow in places and their intention is unclear or inconsistent with earlier statements in the report. This evaluation of the MDNR's plan will be made section by section following the same concept they developed in their draft.

52. The MDNR plan involves 2000 acres of open water to be restored as marsh; 1140+ acres of wetlands to become agricultural cropland for wildlife; 700+ acres in the confined disposal dikes site; 112 acres in dikes and causeways; 160 acres in the wetlands center, headquarters, and nature trail area; and 16 acres in nesting islands for a total impacted area of 4128+ acres.

Marsh restoration

53. The concept of restoring land from an open water situation is not new. It has been used for many centuries in other countries to reclaim lands lost to the sea, especially in lowland countries such as the Netherlands, parts of Italy, and parts of Japan. However, these reclamations were for purposes of food production to feed large populations of people and to allow room for an expanding population to grow. The author is not aware of any place in the world where land has been reclaimed from the sea for purposes of restoring a historic marsh for wildlife habitat. This should be a worthwhile goal at a time when quality habitat is disappearing at a rapid rate, especially in densely populated, industrialized areas like the Great Lakes. A classic case exists at Pointe Mouillee where a heavily used and needed marsh was destroyed over a period of time by natural forces, and the land remained in public ownership so that the possibility for restoration remained alive. When the DD needed a disposal site for the contaminated dredged material from the Detroit River and Lake Erie, they applied a disposal technique unique to this decade in that they decided to build a large diked disposal site in Lake Erie itself, similar to the one completed in 1977 at Toledo. The DD's willingness to locate this disposal dike on the old eroded barrier island, and the MDNR's desire for restoring the former marsh resulted in a unique agreement between these two agencies in a hand-in-hand effort to accomplish the objectives outlined in paragraphs 8 and 10, and to rebuild a wildlife management area of over 4000 acres in a part of the United States where this habitat is scarce and essential to successful migration of many species of avian wildlife.

54. The MDNR's approach to marsh restoration incorporates textbook procedures such as water level manipulation inside dikes to develop marshes to various elevations depending upon the season of the wildlife needs. Their plan also incorporates the rerouting of feeder streams from the marsh so that they will have a better control over water levels. The most unique feature of their marsh restoration concept is the use of hydraulically dredged material to develop marsh land, retention

structures, and islands in the marsh. There is a great deal of engineering technology involved in their design, as well as dependence on their ability to dewater the area inside M1 and M2 so that they can use heavy machinery to build dikes for the islands (and create borrows simultaneously) and build the cross dike. Considering that the bed material inside units M1 and M2 is peat underlain with clay, the areas need dewatering as soon as possible after gates are installed at the north and south causeways so that they will be dry enough for equipment to move. Since the MDNR does not intend to dewater the area, but to only drawdown water levels, the potential for getting heavy equipment on M1 and M2 is nil. There are, however, alternatives to building dikes around nesting islands from borrow material that will be discussed under nesting islands. The HCC has indicated a willingness to work with the MDNR and the DD on location and design of these islands, since it is apparent to the HCC already that without dewatering they cannot enter the marsh units to work.

55. The contractor of the north section of the dike (HCC) has already built the north causeway and installed culverts in it although no gates have yet been installed. The completion of this causeway and the installation of gates at culverts in both the north and south causeway are necessary before drawdown can begin in M1 and M2. Similarly, drawdown of M3 and M4 cannot begin before rerouting of Mouillee Creek, Bad Creek, and Lautenschlager Drain takes place. Also dependent upon an engineering construction project, M1 and M2 cannot be separated and developed as separate units until the cross dike is built with gated culverts. While cross dike construction is taking place, the nesting islands or wings need to be built at the same time while the area is drawn down. The entire development of the project depends heavily on proper sequences and chains of events taking place which involve heavy construction before any biological or marsh restoration work can take place.

Marsh Unit 1 (M1)

56. The marsh. The marsh in M1 will be developed from Lake Erie lake bottom and thus will vary from 2 or more feet deeper than the dikes

which surround it. This could involve some real engineering problems later on, such as dike breaching, dike overtopping by storm tides, failure of gated culverts, seepage from under the dikes (especially the limestone disposal dike before it is sealed), and heavy rainfalls which will make pumping necessary to maintain water levels compatible with the type of marsh being developed. The riprapped dike being built by the DD contractor will be impervious to storms and other similar problems. However, the causeway which has a 7.5 ft elevation above lowest lake level may not be able to withstand overtopping in seasonal storms, especially during high water years in Lake Erie. This will impact the marsh's capability to support winter and spring wildlife, and subject it to erosion from within the dikes as well as from outside the dikes.

57. Since all four marsh units are going to be below Lake Erie water levels, it is assumed for purposes of this report that pumps will be installed in all four units. Although pumps are not mentioned in the draft plan, subsequent conversations with the DD and MDNR personnel revealed that pumps not only are planned but that at least one is in place at the present time.

58. Marsh development will take place readily and naturally after drawdown is complete in M1. Ponded areas will already have ample sources of submerged and floating aquatic plants for propagation of the marsh. Emergent marsh plants will undoubtedly invade M1 without planting the area; however, the species that colonize M1 may not be species which are desirable from a wildlife food and cover standpoint. The list of species the MDNR stated would colonize the area would be excellent, especially if they considered soft rush, river bulrush, chufa, common threesquare, nodding smartweed, and other smartweeds common to the Detroit area. Plant species listed by the MDNR as good possibilities for M1 included arrowheads as well as duck potato and arrow arum. Another plant that could invade the area is wild rice, although this species is notoriously difficult to propagate. If wild rice invades the area naturally, it should be encouraged if at all possible. Most of the above named species have commercial propagule sources and therefore are readily

available with advance notice. These species have varying tolerances to flooding; there are several means by which these degrees of flood tolerance by plants could be used advantageously. All species could be planted in a general mixture (seed mixture as well as a separate vegetative propagule mixture) so that all areas are exposed to all species. Some plants will survive best at their own species-selective elevation whereas other plants will not tolerate certain elevations or water depths and will die. This will ensure good cover and diversity, but will waste expensive propagules, planting time, and money. A better method is to survey the drawdown area and plant patches of tolerant species at suitable elevations, then allow each patch of propagules to spread naturally from the planted area. This will take longer to provide a good vegetative cover, but will work well for diversity. Less competitive species may be crowded out by rapidly spreading stands of other species. If the management goal is to furnish food patches of uniform stands, then planning should be different and monostands of certain species should be deliberately planted with enough spacing so that the next planted patch would offer no competition. Of all three methods of planting, the first one is recommended if the MDNR can afford to waste propagules and the money and labor to plant species that will die at the wrong elevations. If cost is a problem, the second method is recommended over the first, since vegetation diversity should be a management goal and would be beneficial to any wildlife using the area. For more specific information dealing with techniques and flood tolerances, the reader is referred to Environmental Laboratory (1978a), Kadlec and Wentz (1974), Wentz et al. (1974), and Whitlow and Harris (1979).

59. It is recommended that the MDNR plant and allow to colonize more than 70 percent of M1 in emergent vegetation because a portion of these plants will fail when the area is reflooded. Also, there will possibly be some natural subsidence of the marsh with water level manipulations, which will also take away a portion of the new emergent marsh. When the area has been reflooded and stabilized, a balance of about 1:1 open water to marsh should have been achieved.

60. Unless the area has dewatered sufficiently to allow heavy equipment in the area, many of these species will have to be planted by hand on mud flats. An innovative technique that has been used successfully in the southern United States is to seed by helicopter. This includes dropping vegetative propagules such as tubers, rhizomes, and root stock as well. It is also recommended that, if vegetative propagules are used, they be planted on 1/2-m centers rather than the usually recommended rate of 1-m centers. This is to hasten coverage of the marsh with vegetation so that reflooding can take place more rapidly. Wildlife will use the area while it is in the drawdown stage, but will find more cover and use after reflooding has occurred. Planting should probably be done as early after spring migration as is practical to allow maximum growth of the new plantings before the heavy pressure of fall migration occurs. This would help prevent such intense feeding pressure on the new plantings and help their survival chances.

61. Water levels will have to be closely watched, especially during periods of high lake levels and/or heavy rainfall, to ensure that the new marsh is not drowned by rising water that cannot escape the dikes.

62. Fisheries that develop in M1 should be varied and provide good angling for bank and small boat fishermen. The MDNR's concept of leaving or providing uneven pool bottoms will aid in enhancing fishing potential. Fish can either be allowed to come into the area naturally from Lake Erie and the Detroit and Huron Rivers or the area can be stocked to hasten fishing use once reflooding has taken place.

63. Nesting islands and cross dike. M1 is separated from the rest of the area by a cross dike that has not yet been constructed. The cross dike is to be built by the DD contractor from material that must be disposed of and will provide another access road to the disposal dike when the site is completed. The nesting island in M1 is supposed to be built by draglining a dike of clay and filling the dike with silt which the contractor must also dispose of as the dike is built for the disposal area. The silt would be placed by hydraulic dredging.

64. There are problems associated with island construction that must be taken into consideration. Even if the HCC could get a dragline onto the site, there are load problems on the marsh substrate and difficulty in bringing silt slurry to an upland elevation. An island built for nesting purposes should be at least 1-2 m above the highest water level to be maintained in M1. The dike would need to be filled to its top after consolidation or be removed. Many species of waterfowl and shorebirds want access to the water at nest sites and select those sites over one that would present an obstacle to water access (the dike).

65. Another problem that may not be of real consequence, depending upon the HCC dragline work, is the deep water area surrounding the island called for in the MDNR plan. Although the deep water area will provide deep water habitat for fish during water fluctuation, it will also provide hiding places for predators on young ducklings and goslings. Bass, turtles, and other large water animals often feed on these small birds. It is suggested that the contractor and the MDNR consider taking clay for the dike from a borrow area not immediately adjacent to the island. A distance of 10-15 ft from the island could probably be easily achieved with a dragline and would provide a shallow safe area for young birds adjacent to the nesting island while still providing the desired deep water habitat. The shallow area will probably be colonized with emergent marsh plants, which will also provide brood cover more readily than if deep water was adjacent to the island.

66. If the cross dike is to be used as an access road, there will probably not be much nesting use on it. Open water (deep water) habitat adjacent to the cross dike will provide fishing opportunities without affecting nesting potential. However, if the MDNR intends to keep the cross dike as a limited or no access area with the intention of providing nesting habitat, then the technique suggested in paragraph 65 applies here as well.

67. A serious problem with nesting islands is the HCC's inability to get dragline equipment into the marsh units because dewatering will

not take place. After talking with the HCC engineer Robert Johnson (personal communication, January 1980), two alternatives to diked islands appear feasible and will be successful as nesting sites. The islands could be built by unconfined disposal at the originally planned locations since the marsh is essentially confined by the north and south causeways and should not present a water quality problem. The pumped material will contain a sufficient amount of clay that will ball up when pumped through a hydraulic dredge, and this material will mound up adequately to achieve the desired elevation. The second alternative is to build wings or extensions out from the cross dike, the north causeway, and the disposal dike. Construction of up to ten wings that are up to 250-300 m long and up to 50 m wide can be accomplished in the same way as the cross dike will be constructed--by building a firm, above-water foundation in front of the equipment as it moves forward. These extensions into the marsh will require fencing to provide an insular condition; the isolation provided by fencing will serve well for nesting requirements.

68. Managers of Pointe Mouillee may find it necessary at some time to provide predator control since they are providing nesting and brood rearing habitat. The trappers allowed into the area during the trapping season will be distinctly beneficial in this respect, but live- or dead-trapping individual problem animals such as nest-wise raccoons, foxes, or other animals may be necessary as well. Sea gull control is already addressed in another section of this report and the reader is referred back to it if they have a problem with seagulls on the management area.

Marsh Unit 2 (M2)

69. The marsh. M2 cannot be dewatered until gates are installed in culverts at both north and south causeways or at least in the south causeway and the cross dike. It also will be developed from Lake Erie substrate and will be lower in elevation than the surrounding dike and causeway. Although problems in M2 will be similar to M1 there is little danger of storms overtopping the causeway dike and damaging the area because it is protected by both the disposal dike and M1. In addition, M2

is protected by the mainland and the south causeway is very short with little exposure.

70. All aspects of marsh development discussed in paragraphs 58-62 apply to M2 as well. Since M2 is much larger than M1 or the other units, it will have its own problem with winds and subsidence. When the area is drawn down and the water levels manipulated over a period of time, there will be some consolidation of the peat material in M2 and M1. Therefore, more emergent marsh should be planted than is actually desired to compensate for some that will undoubtedly be lost to permanent lodging and subsidence.

71. Nesting islands or wings. The three nesting islands the MDNR plans to build in M2 are closer to human access since they are closer to the area that will contain boat launching ramps and access roads. They seem to be sufficiently distant from the shoreline to be safe for nesting use, however. Construction techniques described for M1's nesting wings or islands should be applied to M2 as well.

72. Vegetation on all four nesting islands or wings, if they are built alternatively, will occur naturally and will most likely consist of smartweeds, red-osier dogwood, sandbar willow, peach-leaved willow, herbaceous plants such as dock, nettle, and others. If wildlife plants that will provide food and cover are desired, such species as reed canary grass, timothy, and others could be planted on the islands or wings. Since these sites are small and other sites on the disposal area are to be provided for bare ground nesters, none of the islands or wings should be planned for use by bare ground nesting species. A fairly dense herbaceous cover will provide cover for waterfowl and will discourage ring-billed gulls as well, since the gulls must have paths through the vegetation to use the sites. They often will nest on bare sites that become covered with seasonal vegetation before their nesting is complete, but they tolerate and use the vegetation quite well. If the site is densely vegetated in early spring, gulls will not use it unless forced to do so from lack of other habitat.

Marsh Unit 3 (M3)

73. M3 is already enclosed within a dike that was erected by the MDNR several years ago. It was eroding on its north side until the DD

contractor rebuilt it as part of the access road or north causeway to the diked disposal area. The area has been used for marshes in the past by the MDNR through water level manipulation and has been planted in food crops to some extent. It also has provided trapping areas for licensed trappers. If the dike were not present, it would have been a completely open water area and part of Lake Erie. Both M3 and M4 serve as cases where reclamation of open water areas for marsh land has succeeded, even though they were reclaimed before the situation became as bad as it is now.

74. If M3 is to be planted in emergent marsh species when the dikes are stabilized and the engineering construction phase of the restoration work is completed, it should be planted with the species recommended for M1 and M2. Aquatic species will colonize naturally; emergent species useful to wildlife already in the area will also colonize and no planting probably will be necessary.

75. Since there are no culverts leading into or out of M3 (or at least none that were mentioned in the draft MDNR plan), it might be wise to install some to facilitate flow of water from M1 or from the Huron River. This would provide a ready supply of water during dry periods; of course, pumping would be necessary to eliminate excess ponding of water in M3. The M3 dike is the most vulnerable dike in the series being built or already built at Pointe Mouillee. The long dike is exposed on the north to a large reach of the Huron River and, except for a finger of land, to the full force of waves from Lake Erie. This dike should be as securely riprapped as the diked disposal area or it will begin to erode in a matter of years and be a constant maintenance problem. If this dike should fail, the entire marsh restoration effort would be in jeopardy since only the outside dikes of the system are being reinforced.

Marsh Unit 4 (M4)

76. M4 incorporates both a marsh area and a wetland agricultural area that is intended for food crop planting each year (Figure 3). Dikes exist for M4 at the present time and will be strengthened when the Mouillee Creek, Bad Creek, and Lautenschlager Drain waters are

diverted by channelization. M4 will be fairly low in elevation and will already contain some large patches of ponded areas even with draw-down. It is suggested that all of M4 be planted with emergent vegetation except for the ponded areas so that about a 1:1 ratio of open water to marsh can be achieved. M4 is an inland diked system and therefore has more protection provided from storms and waves by M3 and the mainland. The marsh area should be treated similarly to M1, M2, and M3. The agricultural area will be discussed under agricultural units.

Dikes

77. The north causeway, south causeway, cross dike, and all other dikes in the system are to be planted with upland grasses and herbs to stabilize them. The interior dikes will probably colonize with shrubs and small trees. If these should become a problem because they limit access to the water to both wildlife and to fishermen, this shrub/tree vegetation may need removal periodically. Otherwise, it should provide screens and cover for the marsh wildlife. Since the clay dikes are extremely slippery in wet weather, the vegetation should be either dense enough to provide traction to access vehicles or a layer of gravel or other surface material should be placed on the dikes.

Agricultural units (A1-A5)

78. The agricultural units plan provided by the MDNR has been one which they have carried out successfully both at Pointe Mouillee and other game areas for many years. Their plan seems to be an excellent one, incorporating diversity, timely crop production, and flooding to allow maximum accessibility to wildlife. No problems or need for improvements are noted.

Ecological center/headquarters/nature trails

79. The plans for this complex are well thought out, and should present no problems in fill and construction. The only problem concerning the complex is that noted earlier with extremely heavy human use. The center is an excellent concept and guides who conduct nature tours can take care to prevent excess human use. Registration and

instruction at the Center will help prevent over-crowding, vandalism, and mischief on nature trails and near nesting and brood rearing areas.

Parking facilities/restrooms/boat ramps

80. Again, the only foreseeable problem with the MDNR plans for construction of human conveniences is the fact that they also provide more accessibility by humans to areas which should remain secluded, such as nesting and brood rearing areas. Warning signs, care in placement, and other considerations should prevent any real problems in this area. Exclusion of parking and boating facilities on the diked disposal area so that only walking access to the diked disposal area is available will help prevent both disturbance to wildlife and vandalism. Authorities have noted that vandals seldom leave the security of their vehicles for long periods when they are intent on mischief. Limited access to the diked disposal area can be enhanced by erection of gated fences which can be used to stop all access if necessary.

PART III: FEASIBILITY REPORT ON A SANTA ANA RIVER MARSH
RESTORATION AND HABITAT DEVELOPMENT PROJECT

by

Charles J. Newling

Introduction

Background

81. The Los Angeles District (LAD) requested DOTS assistance in preparing a feasibility study and conceptual design for restoring approximately 92 acres of tidal marsh adjacent to the Santa Ana River (Figure 4). The proposed marsh restoration would be in conjunction with the proposed Santa Ana River (Main Stem) Project. Also included would be habitat development for the California least tern and possibly other rare species.

82. Personnel from the DOTS team visited the LAD office for a briefing on the project on 4 June 1979 and to the proposed marsh restoration and habitat development site on 5 June 1979. In addition to office and site visits, information was made available to the DOTS team from various District planning documents including the 1977 Final Environmental Statement, historical and current aerial photography, a current topographic survey, and various documents on wildlife and fisheries in the area.

Assumptions

83. Several assumptions were necessary in preparation of this feasibility report:

- a. That a decision has been made by LAD to carry out both tidal marsh restoration and establishment of California least tern feeding habitat rather than other forms of land use to which the proposed 92-acre site may be subjected, and possibly establish nesting habitat as well.
- b. That the exact nature of the salt marsh as it is to be restored has not yet been determined. It could be

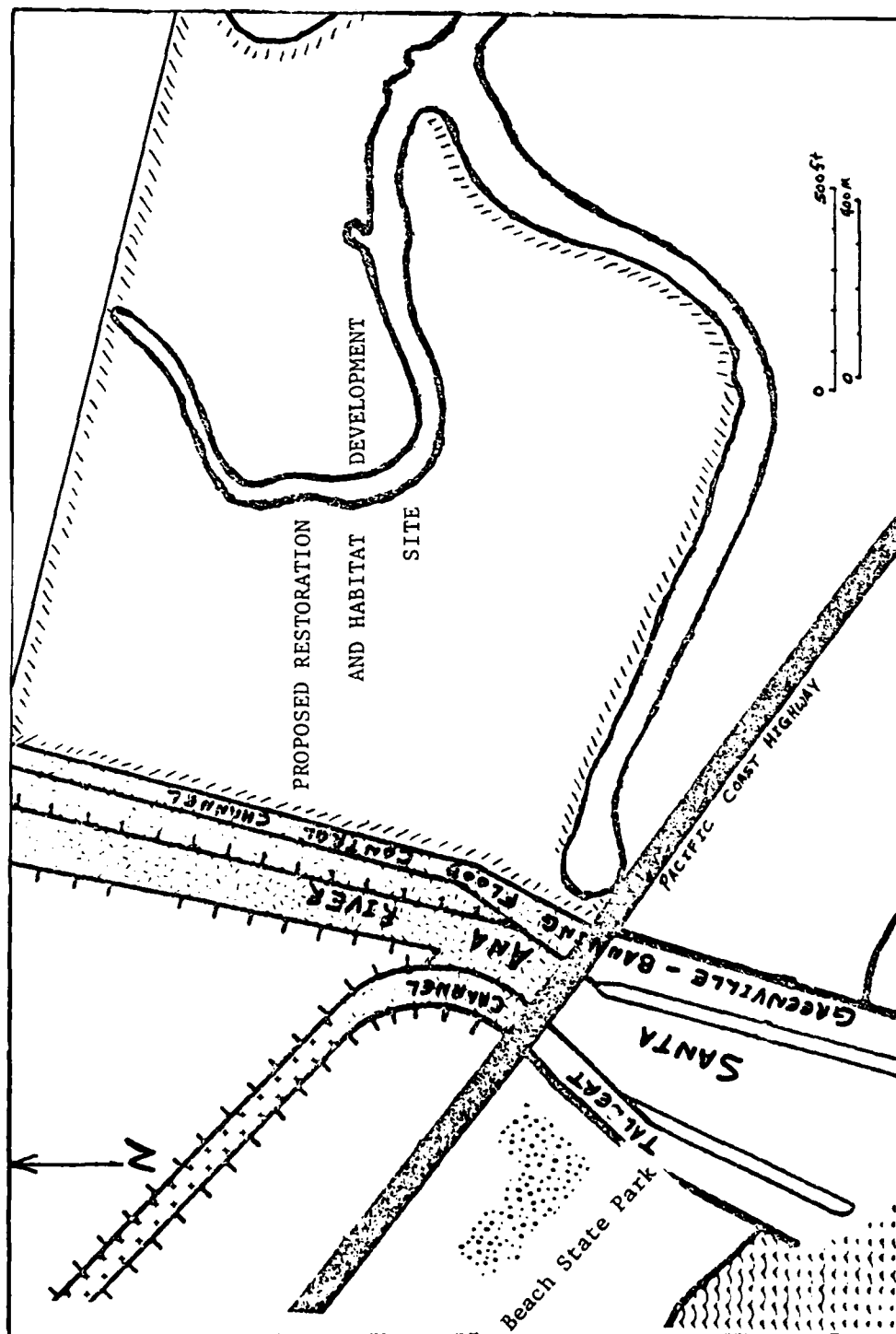


Figure 4. Proposed salt marsh restoration and habitat development site near the mouth of the Santa Ana River, Orange County, Calif.

designed to range in character from monotypic low salt marsh vegetation to a dissected, topographically diverse marsh interspersed with some upland habitat.

- c. That any alternative which could achieve the goals of salt marsh restoration and habitat development could be considered in this report. The practicality and feasibility of several alternatives will be evaluated as the project develops and detailed physical (hydraulics, foundations, etc.) and biological information is gathered by the LAD.
- d. That access to the site will be obtained by LAD for reconnaissance and study purposes.

References

84. The remainder of this report draws heavily from the DMRP (Environmental Laboratory 1978a) and applies principles specifically to the Santa Ana River salt marsh restoration and habitat development proposal. In addition, several other DMRP technical reports are recommended as basic reading for all those actively involved in planning, implementing, or assessing habitat development at this and similar sites (Hunt et al. 1978, Lunz et al. 1978a, Smith 1978, and Soots and Landin 1978).

Planning

Site selection

85. To illustrate the principles discussed in this report, the area illustrated in Figure 4 will be defined as the basic work site for salt marsh restoration and habitat development. When a specific work area is agreed upon and defined, the examples discussed in this report can be modified to fit the appropriate configuration.

86. The proposed site, located in the coastal plain near the mouth of the Santa Ana River, is bounded by the Greenville-Banning Flood Control Channel on the west, a residential community to the south and southeast, bluffs on the north, and undeveloped coastal plain to the north. The LAD considers this area at present to be degraded salt marsh for the following reasons: the source of tidal flow has been reduced

substantially and is now limited to one 36-inch culvert at the southwest corner of the site connecting the outer channel with the Greenville-Banning Channel, undetermined amounts of unauthorized fill material have been placed on the site over a period of years, and it is presently in active use by industrial firms for oil extraction. High tidal marsh still persists on the site, however, and is characterized by plant species including pickleweed, shore grass, and alkalai heath or frankenia. Nomenclature follows Munz and Keck (1959).

87. Tidal marsh development on this parcel of former Santa Ana River floodplain appears technically feasible. The critical element in tidal marsh restoration is that the final surface elevations must lie within the intertidal zone. The normal higher high tides at the proposed site are in the order of +3.3 ft (elevation 0.0 = MLLW), while approximately 80-90 percent of the surface of the site is above that elevation. Restoration of the Santa Ana marsh will require removal of surface material to lower elevations within ranges of tidal inundation compatible for growth of marsh plants.

88. Marsh development has been planned and successfully performed many times in a number of diverse situations as demonstrated by Allen et al. (1978), Clairain et al. (1978), Cole (1978), Kruczynski et al. (1978), Lunz et al. (1978b), and Morris et al. (1978). Palermo and Ziegler (1977) and Vincent (1978) are examples of site specific feasibility studies for marsh establishment. Likewise, considerable work has been done on habitat development and management for colonial nesting waterbirds such as the least tern (Landin 1978b, Soots and Landin 1978). The theoretical concepts of habitat development and the ecological considerations that must accompany the planning of a marsh or upland site are discussed by Lunz et al. (1978a). Smith (1978) illustrated procedural guidelines for selection and development of marsh habitat using dredged material (Figure 5). While the methods of achieving correct elevations differ from site to site (Smith 1978), detailed planning for the Santa Ana River marsh development should employ similar techniques.

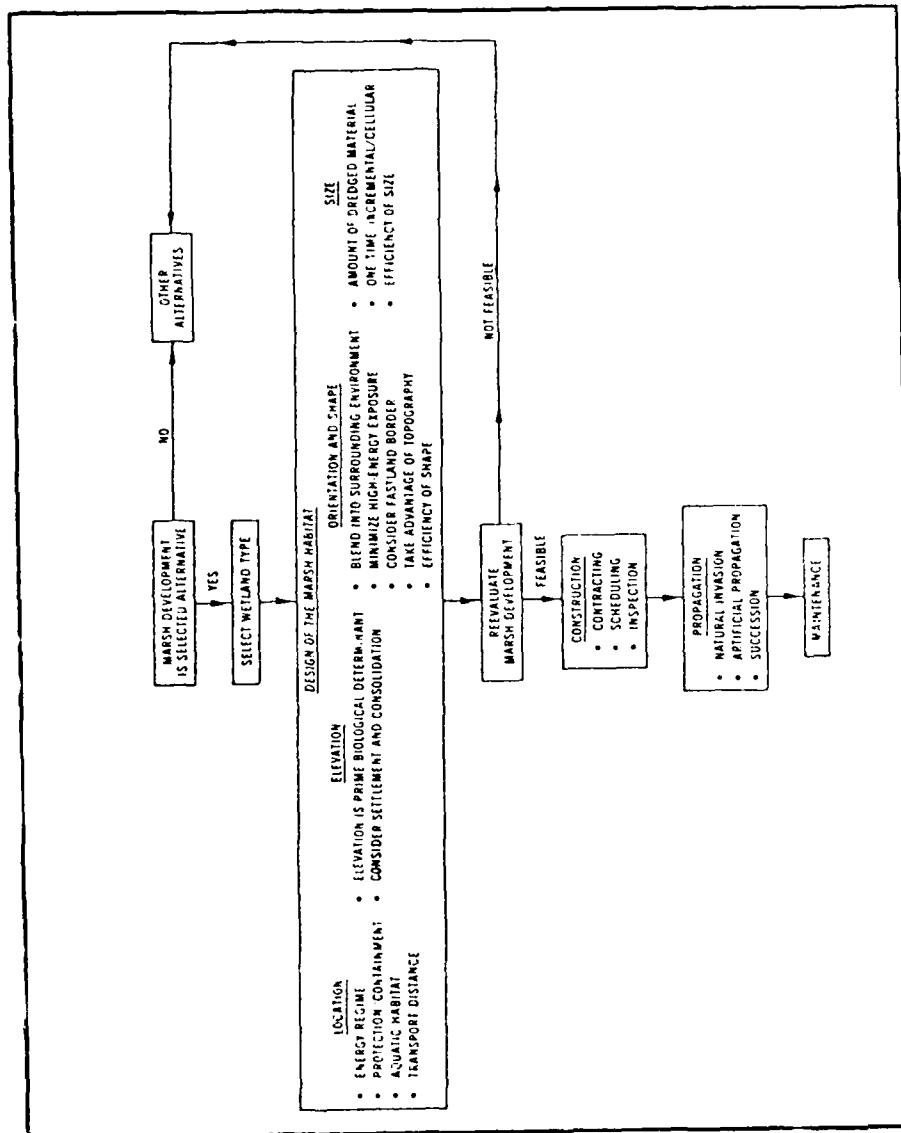


Figure 5. Procedural guidelines for selection of marsh habitat development (Smith 1978:16)

89. In this case, the project must be planned in relation to the site-specific characteristics and project goals, which include salt marsh restoration, providing nesting and feeding habitat for the California least tern, and, if possible, providing habitat useful to both the Belding's savannah sparrow and the light-footed clapper rail and other species. Planning considerations include the following:

- a. Availability of the site. Questions of ownership and disposal agreements through lease, easement, purchase and removal of fill, land use understandings, or scheduling arrangements must be addressed and resolved.
- b. Capacity to meet disposal needs. The site must be large enough to hold the volume of material to be excavated, or alternate or additional sites must be selected.
- c. Disposal authorization. All disposal must receive necessary approval from the appropriate agencies and local authorities.
- d. Physical and engineering considerations. Design and assessment requirements include such logistical questions as the availability of needed equipment and materials, and analyses of soils tests, foundation borings, substrate characteristics, tidal ranges, climatic conditions, quantities of material to be excavated or placed, and other factors.
- e. Environmental and social acceptability. Such factors as alteration of habitat, impacts on existing habitat and wildlife, relative value of habitats under consideration, protection of wetlands or other desirable vegetation, potential for disturbances in water quality or flow, maintenance of tidal flow, and human perception and acceptance of the project should be considered.
- f. Tidal and current considerations. Erosion and scour of habitat areas caused by tidal and wave energies are important considerations for determining the longevity and stability of a habitat development project. Changes in current patterns and the hydraulic regime (including siltation patterns) should be examined.
- g. Costs. Authorization for the overall projects should include funding for habitat development; if not, another funding base must be located. The funding base should be adequate and predictable.

Site characterization

90. Field and laboratory investigations of the site and related areas should be initiated to plan habitat development operations.

Detailed site characterization provides the baseline for documenting status of the preproject site for both planning purposes and subsequent documentation of the success or failure of the project. Specific guidelines are suggested by the Waterways Experiment Station (Environmental Laboratory 1978a, pp 14-17).

91. A topographic map accurate to ± 0.3 ft in the intertidal and subtidal (channels) zone should be prepared. Accurate tidal data and climatic (wind) conditions are required to predict levels of inundation both at the source and extremities of the tidal channels. Water salinity, freshwater flows, drainage patterns, and general water quality should be described and the impact on the project determined.

92. Soils from those layers which, when exposed, will provide the new marsh surface should be cored and analyzed since soil properties will influence choice and success of plant species. Soil analyses should include particle size, N-P-K nutrient levels, pH, salinity, organic matter, and contaminants if any are suspected to be present (heavy metals, oil and grease, chlorinated hydrocarbons, excessive nutrients, and other pollutants). The material removed may also require testing, depending on legal requirements and the choice of a disposal area.

93. Existing plant and animal species at the site should be described, especially the occurrence of valuable habitat. Current fish and wildlife use of the area and potential sources of plant and animal colonization should be identified and determined. For example, California least terns nest in the immediate vicinity at Huntington Beach State Park (Collins et al. 1979) and are likely to colonize any suitable nesting habitat built. Belding's savannah sparrow has been found in the adjacent marsh on the west side of the Santa Ana River (Massey 1978). Aquatic animals including minnow-sized fish and benthos will colonize from the existing marsh channels if they are not too severely disturbed during construction. Pickleweed exists both on and adjacent to the site. No sources of Pacific cordgrass appear to be located nearby and will probably have to be introduced from another California coastal area.

Goal definition

94. To clearly define the habitat development goal, the planner should consider the ecological principles involved, local and regional needs and opportunities, target species needs, available funding, and site or project specific constraints (Environmental Laboratory 1978a, Hunt et al. 1978, Lunz et al. 1978a). As proposed, the Santa Ana River marsh restoration project will rehabilitate salt marsh and provide habitat for California least tern, Belding's savannah sparrow, possibly for the light-footed clapper rail, and for a host of other species that are common to the various habitats that are established. Although the general objective of this project is recognized, a concept of the most appropriate configuration of marsh is needed. This concept should be formulated by consideration of upland and aquatic habitat associated with the marsh as well as human related influences.

Projected plant and animal use of the site

95. California salt marshes are usually characterized by Pacific cordgrass in the low marsh and pickleweed in the high marsh. Pacific cordgrass is a salt marsh grass that ranges southward with patchy distribution along the Pacific coast of North America from Humbolt Bay. Less is known about it than other species of cordgrass. It does, however, grow in the lower and middle portions of the littoral zone of Pacific coast tidal marshes where the salinity is less than 35 parts per thousand (ppt). Generally, the lower and upper limits of its inundation tolerance levels are at 50 and 76 percent of the local tidal range, respectively (Macdonald and Barbour 1974). At the Santa Ana River site, Pacific cordgrass will probably survive between elevations 1.2 ft and 3.3 ft with its heaviest growth between elevations 1.4 ft and 2.4 ft (elevation 0.0 ft = MLLW) where frequency of tidal inundation to a large degree appears to eliminate growth by other less tolerant species. Above elevation 2.4 ft, pickleweed as well as other more salt tolerant species will become dominant, while Pacific cordgrass will become less common due to its low tolerance for the higher salinity which is common to California high marshes. Pickleweed is a widespread

species exhibiting a broad range of tolerance within and above the intertidal zone and can withstand extremely saline conditions. Its heaviest growth usually occurs within the upper littoral zone and into the maritime zone. At the Santa Ana marsh site, heaviest pickleweed growth will probably occur from elevations 2.4 ft to and above 4.0 ft depending on soil moisture and salinity. Figure 6 is a flow chart demonstrating conditions necessary for successful propagation of Pacific cordgrass. Figure 7 is a schematic diagram charting the zones of tolerance to tidal inundation for species likely to be successful at the Santa Ana River site (Environmental Laboratory 1978b).

96. California least tern. The California least tern once bred in abundance along much of the lower Pacific coast. As a result of human pressures, however, both nesting and feeding habitat have been drastically reduced resulting in a precipitous reduction of its population (Massey 1978). It is now on the Federal Endangered Species List (Federal Register, 17 January 1979). The protected Huntington Beach State Park nesting population, located on the beach just west of the mouth of the Santa Ana River, is one of the largest left in the region and is a source of birds for potential colonization of the proposed habitat development site if it is made suitable for nesting. Breeding birds arrive around the end of April and usually complete nesting activities and have left by 15 August, although in some years they do not leave until early September (Massey 1978). The birds nest on relatively flat, barren, sandy areas, 1 to 3 yds above the highest tide levels. They usually prefer a stabilized sand (commonly dredged material) that will not blow in the wind or shift, but also use shell and pebble substrates. Least terns tolerate little or no vegetation on their nesting area and require complete protection from disturbance by humans and other predators (Soots and Landin 1978).

97. Adult least terns eat small fish up to 2-4 in. in length, but the chicks require smaller sized fish. The Huntington Beach nesting colony appeared to be highly opportunistic in fishing efforts, utilizing a variety of areas wherever fish of a suitable size were available

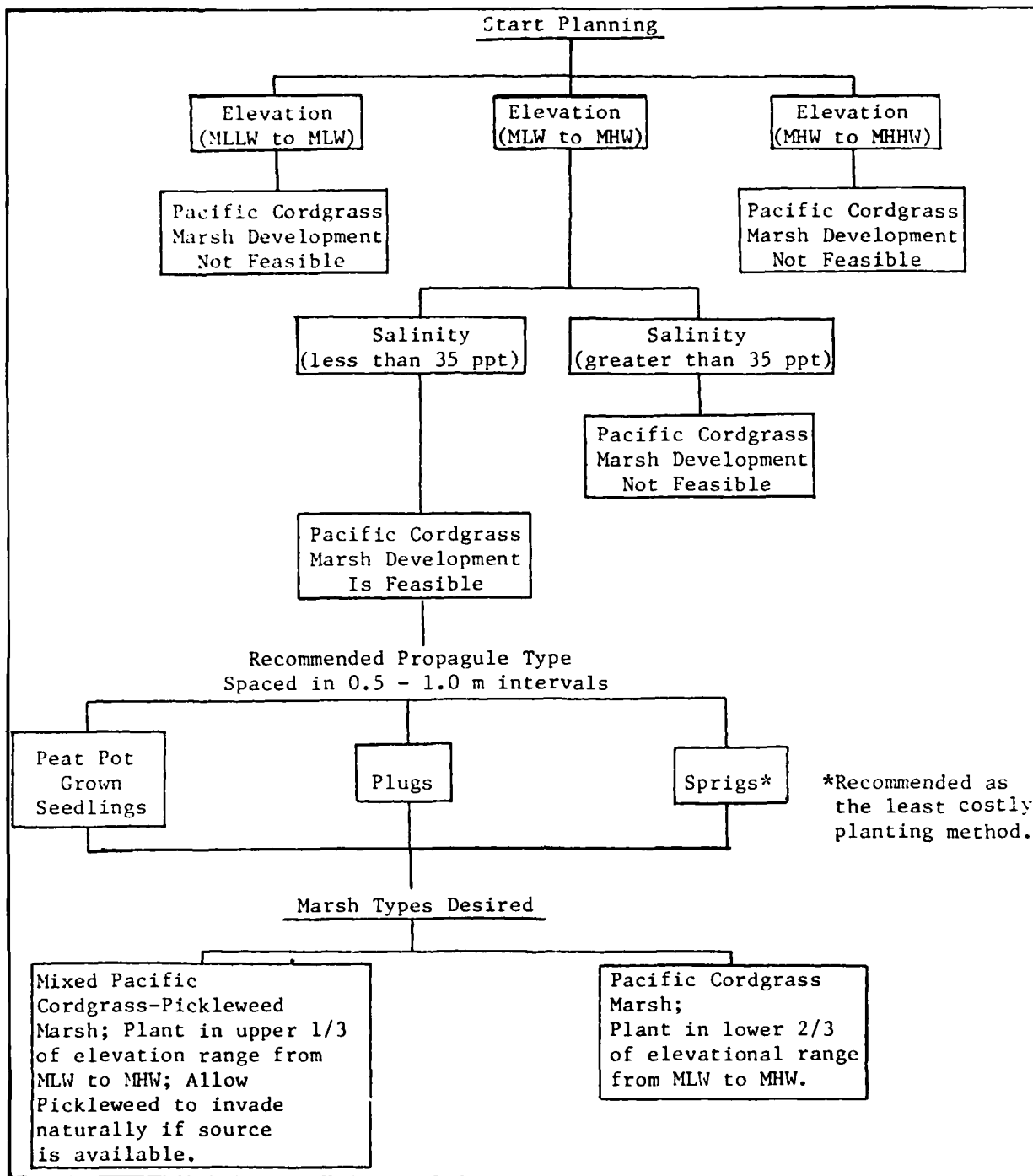


Figure 6. Flowchart demonstrating conditions necessary for successful propagation of Pacific cordgrass (*Spartina foliosa*). (Source: Huffman, R. T. Unpublished draft report. Recommended planting procedures for marsh development on confined substrates within South San Francisco Bay, California. U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.)

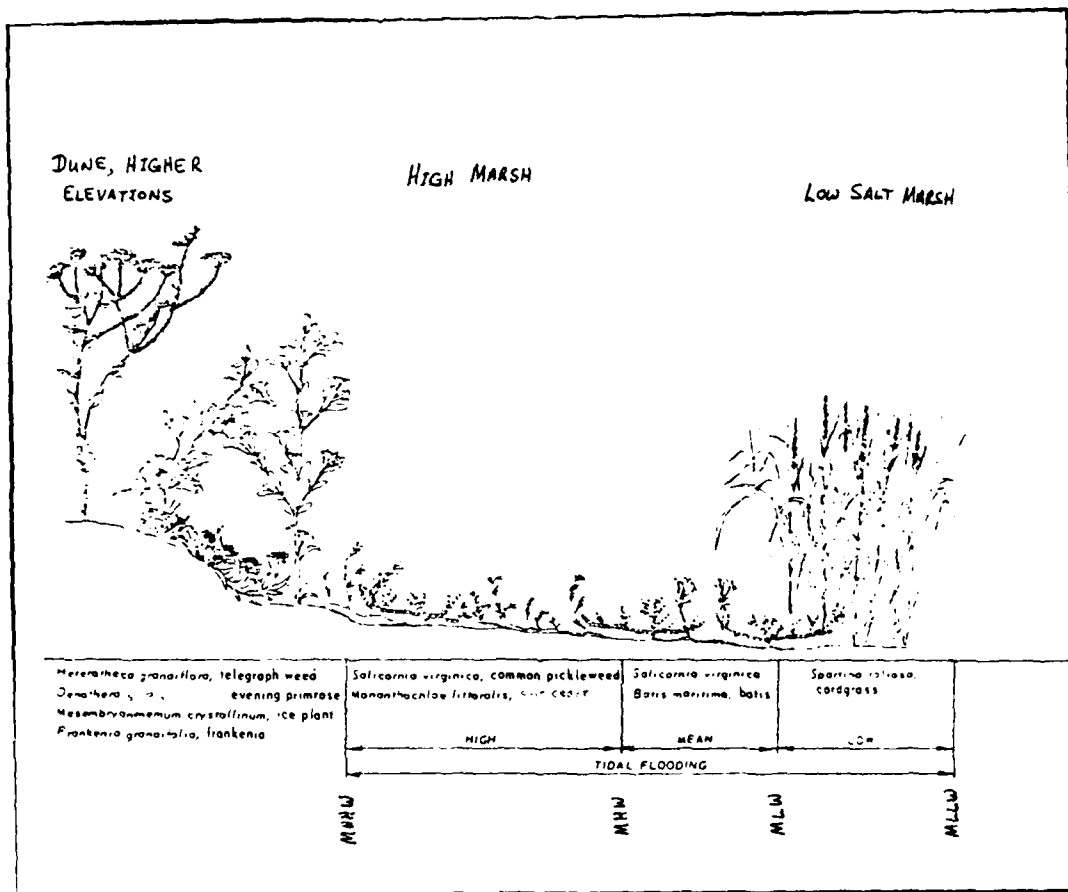


Figure 7. Generalized salt marsh profile showing plant associations and usual occurrences in west coast tidal marshes

(Collins et al. 1979). The birds preferred areas near the nesting colony for fishing. Since the least tern does not plunge dive, but takes its food from just below the surface, shallow water has always been considered a requirement for least tern feeding. Near the mouth of the Santa Ana River, California least terns fished in both the river and adjacent flood control channels, but appeared to prefer the shallower river. It should be noted, however, that during 1978 observations of the Huntington Beach colony it was clearly demonstrated that the open ocean and nearshore area were the most heavily used of the least tern foraging areas censused (Collins et al. 1979). While the amount of foraging habitat may not be as critical a need of the California least terns as nesting habitat, there is little doubt that enhancing local populations of minnow-sized fish would benefit the least terns. Additional information is provided on the least tern and its biology and habitat requirements by Landin (1978c), Massey (1971, 1974), Soots and Landin (1978), and Wilbur (1974, 1977).

98. Belding's savannah sparrow. The Belding's savannah sparrow is a small songbird which inhabits some coastal salt marshes of southern California. Because of severe decline in its population in recent years, due mainly to habitat destruction, the bird was placed on the California Endangered Species List in 1974. The Belding's savannah sparrow has a very close association with pickleweed, spending most of its life in or near dense stands of the plant in coastal high marsh. Not only is pickleweed the preferred plant in which it builds its nest, but also the birds are known to eat the succulent growing tips of pickleweed branches. Generally, however, the birds prefer a diet of insects foraging on the ground in all three littoral zones and in the maritime zone. The females use dry pickleweed twigs in building their nests. The males use the highest branches as sunning perches and in establishing breeding territories. Pickleweed stands above the highest spring tide are the preferred nesting sites. Territories are established first in late November and early December; the primary song is heard from late December to late January. Nesting proceeds through the spring and early summer and the last chicks are fed between July and August (Massey 1979).

99. Nesting densities as great as 14 breeding territories per acre have been observed on an Anaheim Bay salt marsh, but Massey (1979:11-12) considered these conditions optimal. If breeding pairs are found in a salt marsh at all, much lower densities are usually observed. In 1977, only six breeding pairs of Belding's savannah sparrows were observed in the 17-acre remnant salt marsh west of the Santa Ana River and adjacent to the proposed habitat development site. None were observed on the site itself. It is, therefore, unlikely that habitat development activities on the site would adversely affect Belding's savannah sparrows. What is not known is whether or not an adequate source of Belding's savannah sparrows exists for colonization of newly developed habitat.

100. Light-footed clapper rail. The light-footed clapper rail, a marsh bird of the lower littoral zone, is also on the Federal List of Endangered Species (Federal Register, 17 January 1979). Nesting in dense Pacific cordgrass at lower elevations, its eggs can apparently stand partial inundation. Less is known about the light-footed clapper rail than the two birds species previously mentioned and it has not been observed in the near vicinity of the proposed project site. However, measures promoting establishment of dense Pacific cordgrass stands in lower littoral zone situations may provide suitable habitat.

101. Other uses. Additional efforts on the site could be featured if they do not conflict with the primary goals of the project. For instance, a nature walk could be established through the area with observation towers or blinds located at strategic points for observing birds and other wildlife on the restored marsh. Positioning a nature walk would require great care as the least terns are considered extremely intolerant of human encroachment on their nesting area. However, the site is large enough so that it may be possible to find an acceptable observation point which could be used as an educational feature of the project.

102. Another possibility that may be considered is to attempt the establishment of unusual or rare plant species native to California coastal marshes. Designated portions of the site could be tailored to the specific needs of the plant species chosen.

Potential planning problems

103. The planner should be aware of regulations, problems, or delays that can surface during some phase of the project (Environmental Laboratory 1978a:18-19). Many potential problems can be averted with additional coordination or preventative action such as public meetings, discussions with special interest groups, or meetings with local officials and State and Federal agencies. In addition to stipulations presented in local public health and mosquito control ordinances, the National Environmental Policy Act of 1969 and the Endangered Species Act of 1973, close attention should be given to the provisions of the Clean Water Act of 1977, particularly requirements of Section 404 regarding filling activities. Further, questions of access, ownership, and funding must be resolved. Consider these questions:

- a. How much money is available?
- b. When will it become available?
- c. Over what period of time is the money available?
- d. How certain is the funding?
- e. Are there items for which it cannot be used?
- f. Are there time limits on its expenditure?

104. Potential problems relating directly to the proposed Santa Ana River site should be considered during the planning process. These may include the following:

- a. River flood crest elevations must be taken into account before finalizing the size and elevation of culverts or breaches at the site to ensure that no chance of local flooding of developed upland residential areas exists.
- b. Soil salinity on the restored area must be considered. Elevations that are too high, inundation occurring too infrequently, or piping through saline soils may all increase soil salinities and favor salt-tolerant plant species such as pickleweed. If cordgrass is desired, conditions more saline than sea water (i.e., 35 ppt) should be avoided.
- c. The timing of construction must be planned and implemented during the nonbreeding season of the wildlife species which are or may be using the site.
- d. Mosquitoes have been a problem on some habitat development sites using dredged material substrates (Ezell 1978).

Designing the site with adequate slope to ensure frequent tidal inundation and flushing thus avoiding shallow, stagnant conditions will reduce the possibility of a mosquito problem. Early coordination with both the local mosquito control board and public health agency will help eliminate potential conflicts later in the project.

- e. Any fill or dredged material deposited in water or wetlands of the United States is bound by regulation under Section 10 of the Rivers and Harbors Appropriations Act of 1899 and/or Section 404 of the Clean Water Act of 1977 (Public Law 92-500). Any plans for the marsh restoration project should be reviewed by the LAD Regulatory Functions Branch to determine the applicability or need for 404(b) guidelines review or other regulatory clearance. Likewise, the plan involving the California least tern and the light-footed clapper rail should be coordinated through the U. S. Fish and Wildlife Service Regional Office of Endangered Species.
- f. Capacity to meet disposal needs must be determined for whatever restoration alternative is chosen; availability of acceptable disposal alternatives for excess material should be determined by the LAD.
- g. A reliable source of capping sand for the least tern nesting area must be located. Is sand available in the near vicinity? Consider also how often the nesting area may require periodic capping or plowing to eliminate unwanted vegetation.
- h. Opening tidal channels on the site to greater tidal exchange may reduce water levels at low tides to a point sufficiently shallow to prevent small craft use during low tides. Hydraulic and tide studies on the site should address this possibility, and an impact assessment should be made of social problems this may create in the local neighborhood.

Development of the Site

Field and laboratory investigations

105. Successful design and implementation of marsh restoration and habitat development will require detailed analyses of tidal regimes, climatic conditions, and hydraulic, foundation, and soil characteristics for both engineering and plant propagation requirements. For general guidance, the planner is referred to Environmental Laboratory (1978a:20-55), Palermo and Ziegler (1977), Hammer and

Blackburn (1977), and Eckert et al. (1978), which include engineering aspects of substrate design. For guidelines to characterize soils, consult Bartos (1977); and to predict their capability to support various types of vehicles, consult Willoughby (1978). Several site specific points listed below should be addressed.

106. Accurate determination of tidal characteristics on the site itself are crucial. All elevations used in this report are based on elevation 0.0 ft = MLLW with tidal heights determined from the 1979 Tide Tables for the West Coast (U. S. Department of Commerce 1978). The following tidal regime was listed for a station located inside the mouth of the Santa Ana River:

Extreme high (for 1979)	3.9 ft MLLW
Mean higher high water (MHHW)	3.3 ft MLLW
Mean high water (MHW)	2.6 ft MLLW
Mean tide level (MTL)	1.4 ft MLLW
Mean low water (MLW)	0.2 ft MLLW
Mean lower low water (MLLW)	0.0 ft MLLW
Extreme low (for 1979)	-0.4 ft MLLW

The mean tidal range is 2.4 ft and the diurnal range is 3.3 ft. These data are used throughout this report for the purposes of discussion, but they may not adequately characterize tides on the salt marsh restoration site. Tide gauge studies should be conducted to determine tidal regime both at the mouth of the marsh channel, as well as far upstream into the marsh itself. Only a detailed study on the site itself will provide inundation and tidal information sufficiently accurate for the purposes of tidal marsh restoration.

107. Careful determinations of Santa Ana River flood crests and tidal flows must be made to ensure that flooding of local residential areas will not occur. It appears that a water level reaching elevation 6.9 ft in the Greenville-Banning Channel will overflow the site as it presently exists. Floodwater in the marsh which reaches an elevation of approximately 6.5 ft would appear to cause street flooding in the residential area southeast of the proposed marsh. In planning the size and elevations of the culverts or breaches necessary to permit adequate tidal

inundation for marsh restoration, potential for excess water must be considered. If the potential for flooding exists, flap-gated culverts may be required. Field studies of tides and hydraulics should be designed to address the following questions. Will tides be substantially different far up the channel as compared to near the mouth, thus altering the size of the zone within which marsh plants can grow? Can enough water pass through the culverts or through a breach to adequately flood the area under normal tides? How much of the area can be flooded with normal tides? How much water can both the existing Greenville-Banning Channel width and the proposed main stem project configuration pass under normal conditions? Can elevation of culverts be raised to maintain minimum water depth in the marsh channels at all times and still receive daily high tides? How likely is it that such water might become excessively saline for Pacific cordgrass? How fast will flow velocities be at the mouth of the stream(s)? Is erosion likely to occur? How fast will the area fill in with silt? Answers to questions such as these are necessary to successfully design the project.

Some habitat
development alternatives

108. Tidal inundation is necessary for the salt marsh restoration. The existing 36-in. culvert connecting the southwest corner of the exposed site with the Greenville-Banning Channel is inadequate for salt marsh restoration. Breaching the earthen dike between the outer marsh channel and the Greenville-Banning Channel would be the simplest measure for restoring unimpeded tidal flow. It may be desirable, however, to maintain vehicular access to the interior of the site by way of the roadway which presently exists on the earthen dike. If this is the case, culvert installation would be required to provide the required tidal flow. The size and number of the culverts would have to be based upon results of the tidal and hydraulic studies conducted on the site. The culverts must pass sufficient volumes of water quickly enough to ensure adequate tidal exchange twice daily. Culverts with flap gates to close off flow to the marsh area when necessary may

be required if the tidal and hydraulic studies indicate any potential for backwater flooding which might affect adjacent residential areas.

109. It is suggested that one or two locations within the proposed site be utilized for development of least tern nesting habitat. As illustrated in Figure 8, both areas A and B would be suitable locations to take advantage of existing high elevations on the site. Some of the excavated material from other portions of the site could be disposed here bringing respective elevations up to a maximum of approximately 12 ft, ranging between 10 ft and 14 ft. Part of this total would have to include sand capping material. The following procedures are suggested for successful development of the nesting habitat: depth of the capping sand should be sufficient to retard plant growth on the nesting habitat; the surface should have sufficient slope to prevent ponding of rainwater; the nesting habitat will require fencing to prevent disturbance; and yearly management consisting of removal of invading plants by hand-pulling or plowing will be a necessity to maintain the habitat in suitable condition for least terns.

110. Area A is approximately 11 acres in size, roughly twice the size of the area presently used by the California least tern colony at Huntington Beach State Park. If it is well protected from human disturbance and predators, it should serve adequately as additional nesting habitat. Area B would provide an added margin of safety and room for population expansion of the least terns by creating another, separate nesting site. As proposed, Area B is approximately 3.7 acres in size. If elevations were raised to an average of 12 ft (including the sand cap), Area A could contain approximately 117,000 cu yd of material and Area B could contain approximately 38,000 cu yd. Any excess of excavated material would have to be disposed of elsewhere.

111. Restoration of the marsh will require not only a source of tidal inundation as discussed previously, but also removal of existing substrate in order to lower elevations within the range of tidal inundation. Based on predicted tide levels and requirements of the desired marsh species, those areas lowered to elevations between 2.6 and 4.0 ft should support pickleweed. If tidal inundation is provided twice

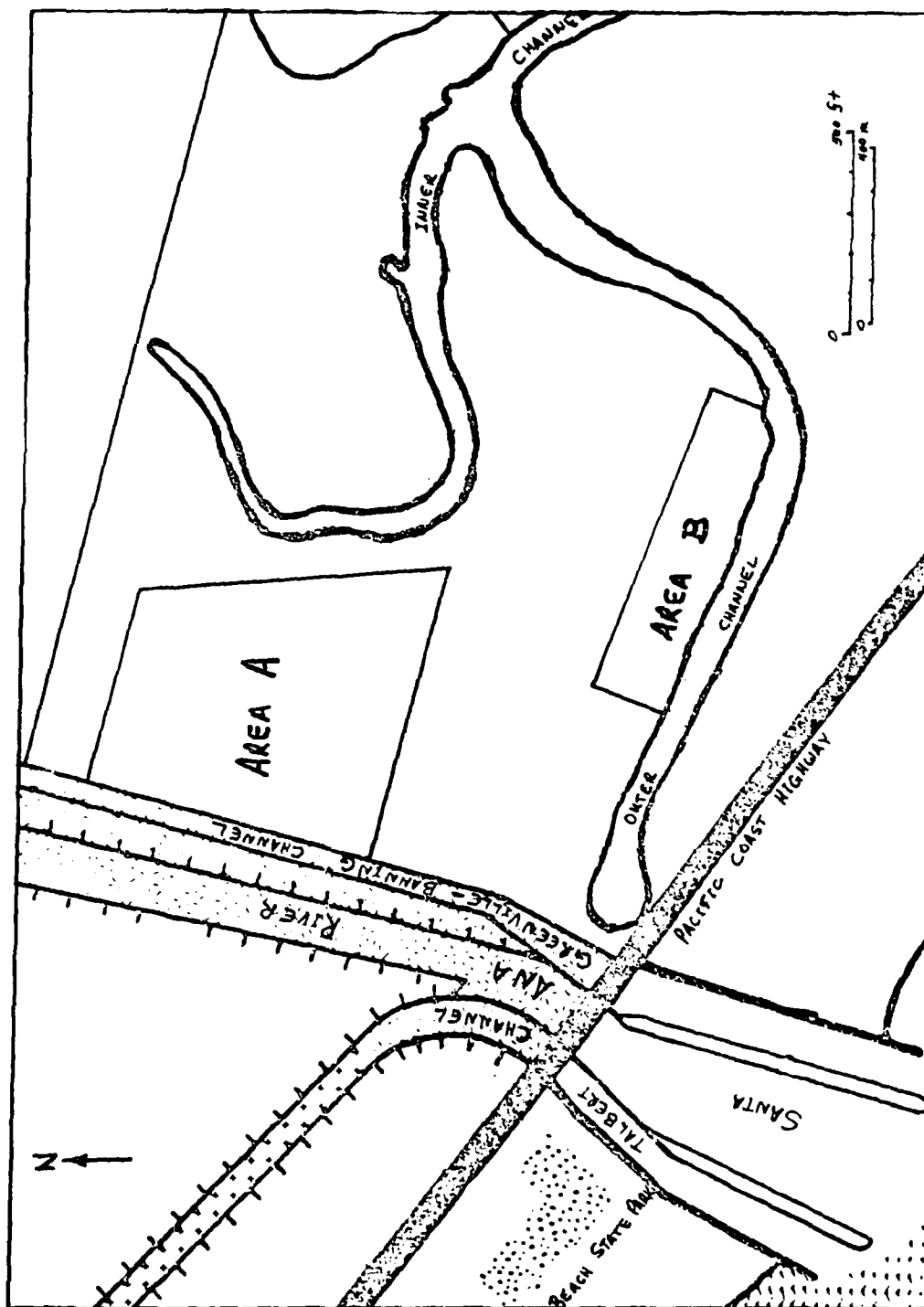


Figure 8. Proposed locations for development of California least tern nesting habitat (Areas A and B)

daily, areas lowered to elevations between 0.0 and 2.6 ft should support Pacific cordgrass and bare mudflat habitat. Heaviest Pacific cordgrass growth should occur between elevations 1.4 and 2.6 ft. Areas lowered to less than 0.0 ft should remain subtidal.

112. Alternative 1. Reducing elevations on the site to a maximum of 4.0 ft sloping to a minimum of 2.6 ft along the existing channels would provide suitable conditions for a monotypic high marsh dominated by pickleweed. Approximately 120,000 cu yd of material would have to be removed. After the initial planting effort, this high marsh would establish cover quite rapidly and, except for the least tern nesting areas, provide extensive potential habitat for the Belding's savannah sparrow and other high marsh species.

113. Alternative 2. Reducing the maximum elevations to 2.6 ft and the minimum elevations within a variable range between 1.4 and 0.0 ft would provide suitable conditions for a monotypic low marsh dominated by Pacific cordgrass. Approximately 256,000 cu yd of material would have to be removed. After the initial planting effort, this low marsh would establish cover at a slower rate than the high marsh and, except for the least tern nesting areas, provide extensive potential habitat for the light-footed clapper rail and other low marsh species. The slower growth rate is a characteristic of Pacific cordgrass.

114. Alternative 3. A combination of the two alternatives just described is illustrated in Figure 9. This alternative provides potential habitat for both low and high marsh species. Elevations outside of the two least tern nesting sites (Areas A and B) range from 4.0 to 0.0 ft. The gradation between low marsh and high marsh should occur between elevations 2.0 and 3.0 ft. The three alternatives that have been described thus far are based on the existing channel configuration from which desired contours are projected. Assuming there is an adequate source of water for intertidal flow, much more complex alternatives with greater wildlife value are available.

115. Collins et al. (1979) found that the existing outer channel of the marsh was used often by foraging least terns from the nearby nesting colony. Taking advantage of the prevailing westerly winds the

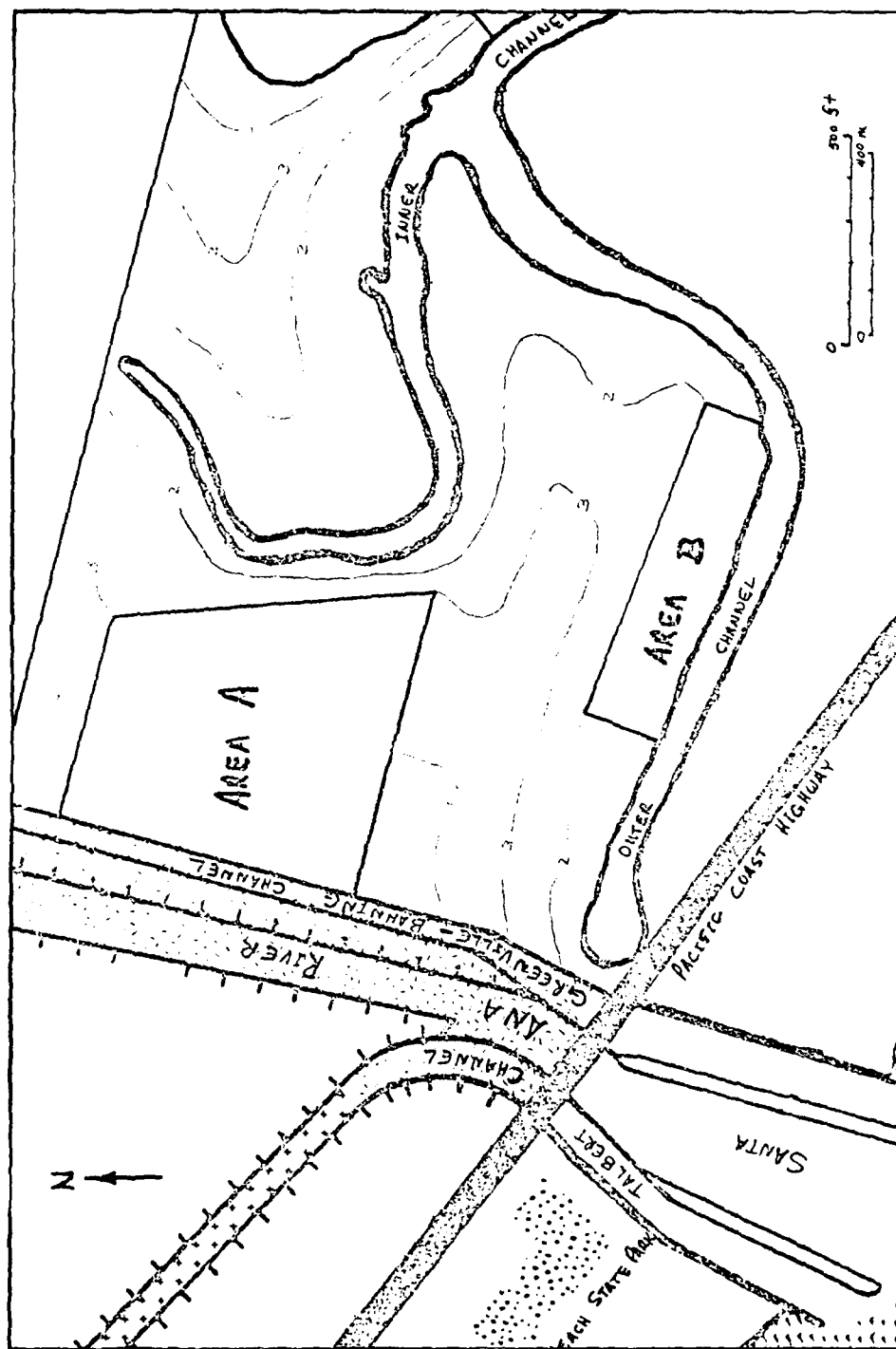


Figure 9. A configuration for habitat development providing low and high marsh with two elevated least tern nesting sites (Areas A and B). Low and high marsh intergrade between elevation 2.0 and 3.0 feet (MLLW).

least terns forage slowly upwind from east to west. Upon reaching the west end of the channel, they return quickly downwind to the east end of the channel and repeat the process. Taking this behavior into consideration, additional alternatives for habitat development are suggested based on the creation of more east-west channels.

116. Alternative 4. Figure 10 illustrates a possible habitat development alternative involving the addition of new east-west channels and the creation of two least tern nesting areas. Moving from channel bank up to the base of the nesting area, elevations rise from 0.0 to 4.0 ft providing channel, mudflat, low marsh, and high marsh habitats. Between channels, maximum elevation is 4.0 ft decreasing gradually to 0.0 ft and providing similar habitat intergradation. This configuration would provide nesting and shallow-water foraging habitat for California least terns as well as habitat for both low and high marsh species. If maximum elevations were set at 5.0 ft, the 4.0 to 5.0 ft elevation zone would support maritime vegetation providing even greater habitat diversity to the restoration site and increasing the number of potential wildlife and plant species that could inhabit the site.

117. Alternatives 5 and 6. Figure 11 shows a cross section and plan view of habitat which could be developed at the Santa Ana River site based on a 3.33-percent slope ranging from elevations -1.0 to 4.0 ft. Figure 12 shows a similar cross section and plan view based on a 4-percent slope ranging from elevations -1.0 to 5.0 ft. When placed side by side in continuous bands, these configurations repeat in intervals of 300 ft. Within these elevations, considerable habitat diversity is possible. Twisting these narrow bands of habitat around the sinuous contours of the marsh channels tends to intersperse the habitat types, thereby greatly increasing the value of the entire area to wildlife.

118. In order to encourage feeding by the least terns channels must be sufficiently wide. Collins et al. (1978) reported that least terns foraged in the existing outer marsh channel, but did very little foraging in the narrow inner marsh channel which was overhung by

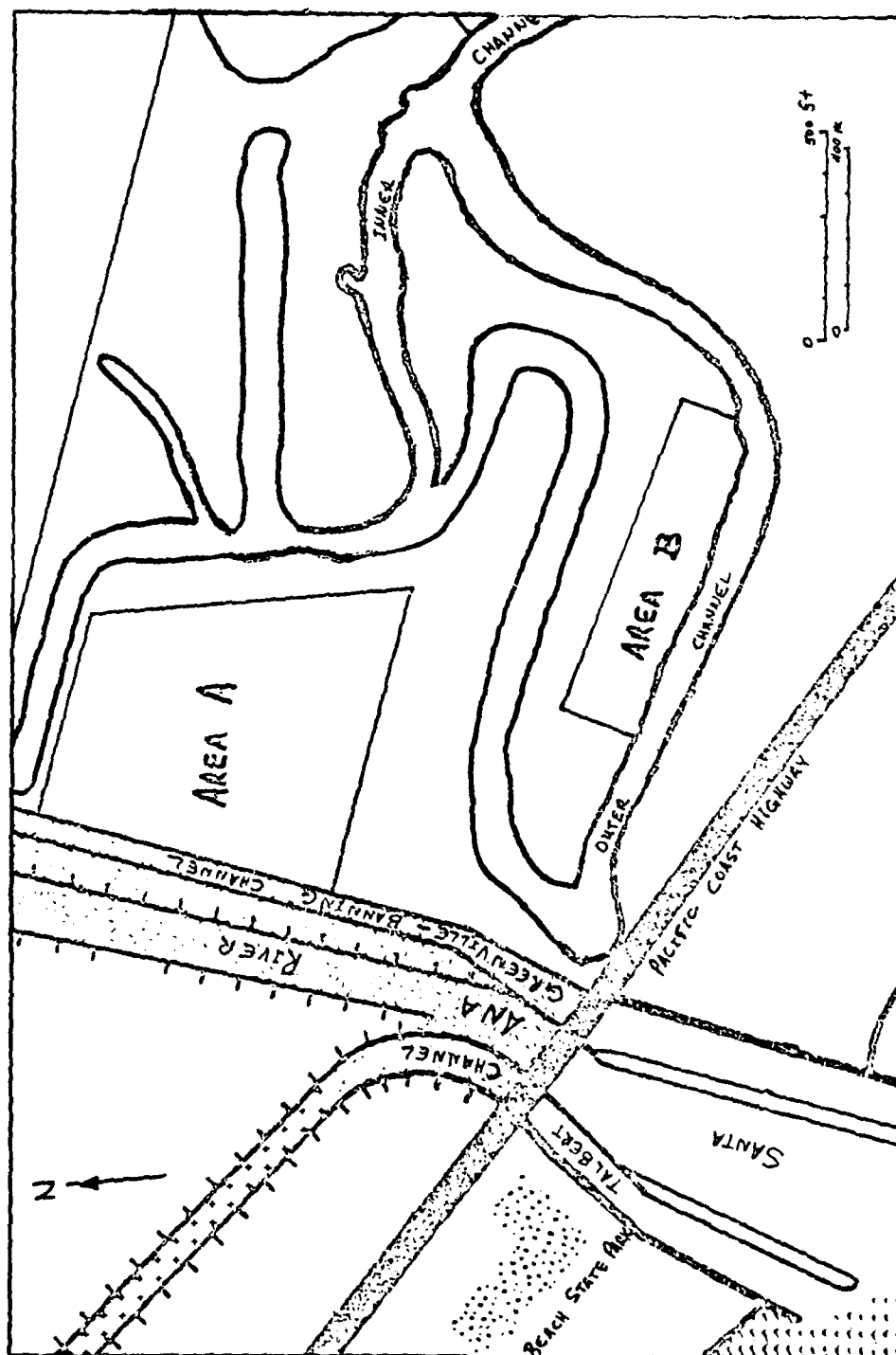


Figure 10. A configuration for habitat development providing two least tern nesting sites (Areas A and B) and additional east-west oriented tidal channels

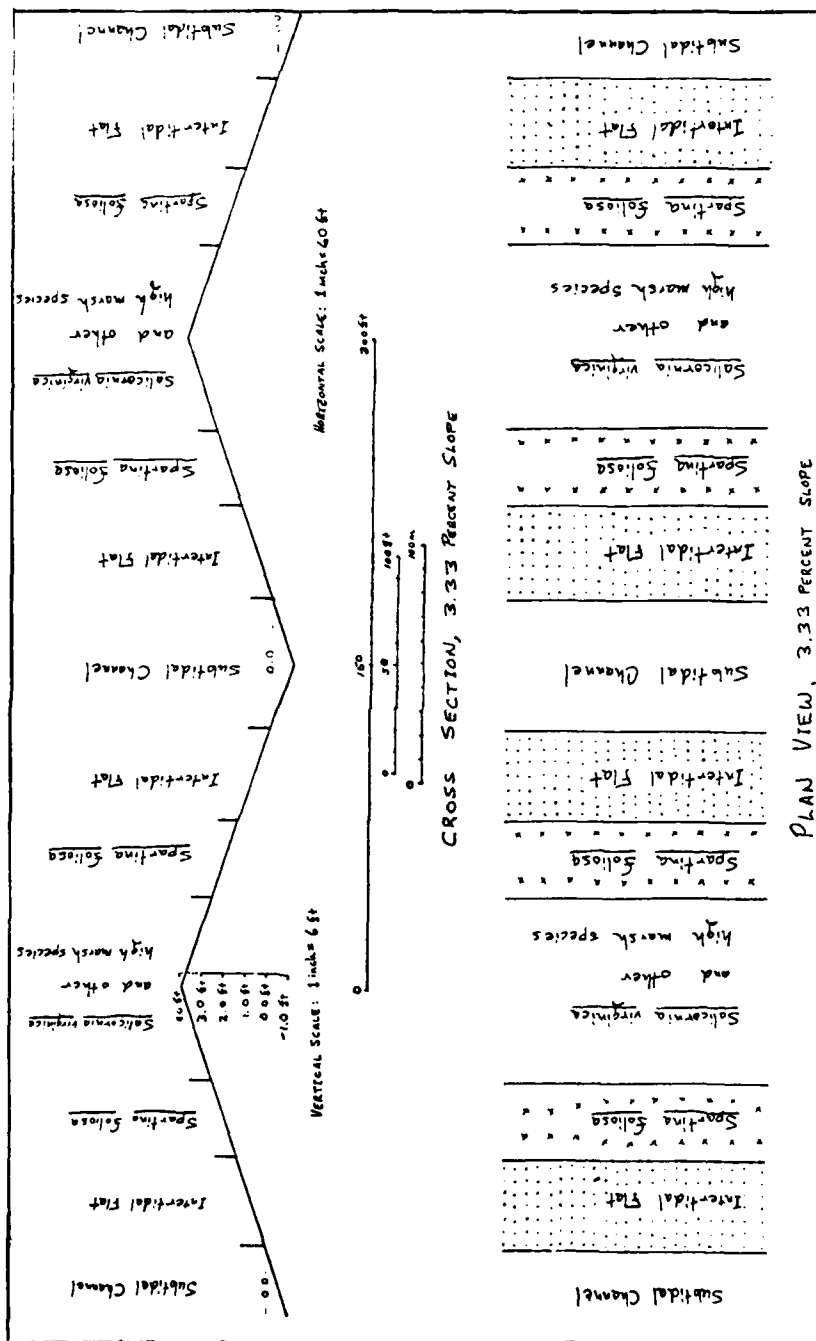


Figure 11. Cross section and plan view of a possible habitat development configuration for the Santa Ana River site based on 3.33 percent slope ranging from -1.0 to 4.0 feet (MLLW) (note that the vertical scale is expanded)

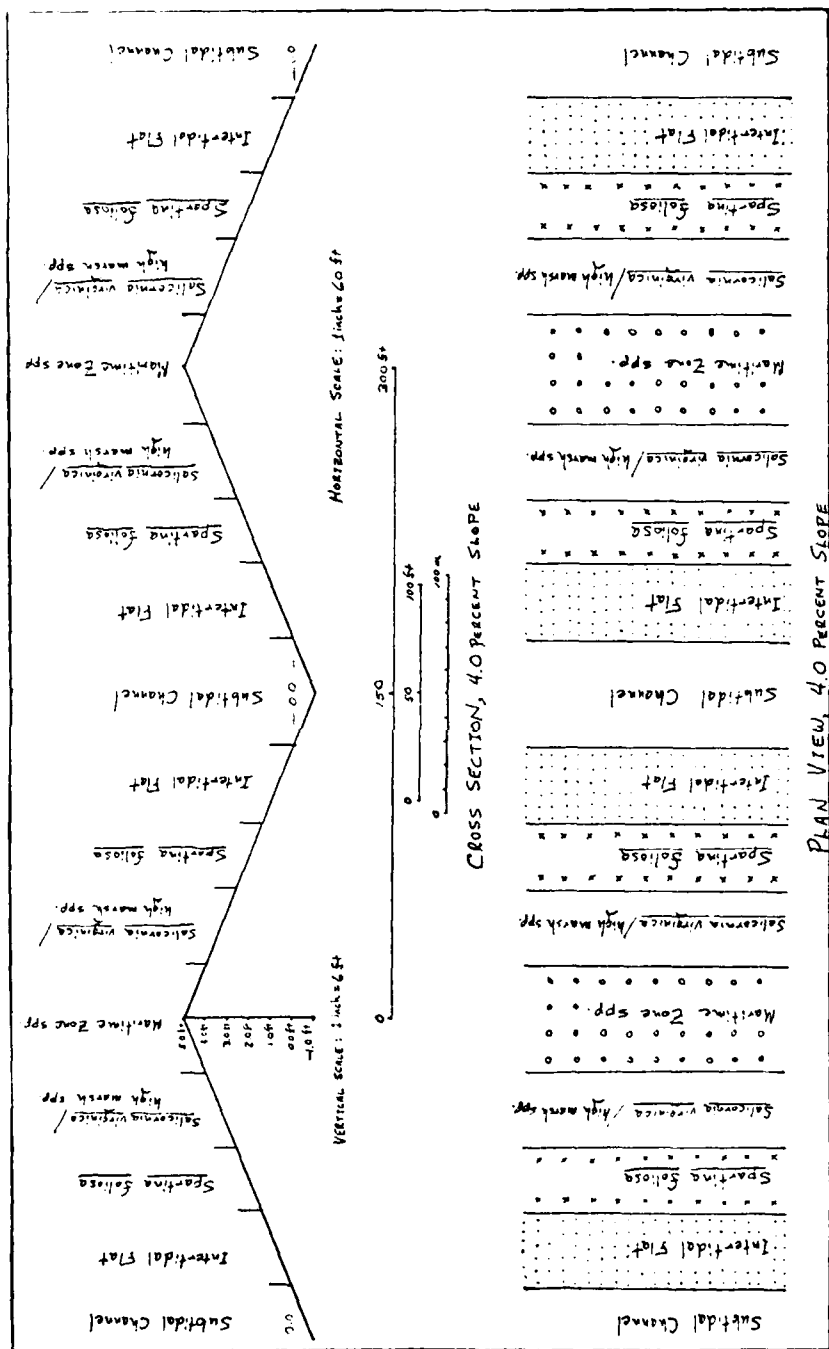


Figure 12. Cross section and plan view of a possible habitat development configuration for the Santa Ana River site based on 4.0 percent slope ranging from -1.0 to 5.0 feet (MLLW) (note that the vertical scale is expanded)

vegetation. On the other hand, the addition of similar narrow channels would provide protected areas for fish.

119. It appeared that the clear water of the Santa Ana River enabled least terns to see small fish from a great distance (Collins et al. 1979). The constantly turbid, dark-brown appearance of the water in the Talbert Flood Control Channel may account partly for the much lower use of this area by fishing least terns since they are visual feeders (Soots and Landin 1978). This suggests that clear water and light colored bottoms may optimize fishing conditions for least terns and may be desirable objectives in habitat development. The Banning Channel and the Santa Ana River have light sandy bottoms, whereas the Talbert Channel, which was less used for foraging, appears to have a bottom consisting of dark mud with clusters of mussels. The inner marsh channel has mud (dark-colored) bottoms, but reasonably good water clarity. The outer marsh channel also has a relatively dark colored bottom which appears to be heavily used by the least terns during the period when they are feeding newly hatched young chicks; these chicks require smaller food fish than the more nearly full-grown chicks or adults (Collins et al. 1979).

120. Any artificial channels created would probably have water clarity similar to that in the existing marsh channels. If the exposed substrate also was dark, attempts could be made to line the channels with sand. This is not recommended, however, because with time the channels are likely to become dark bottomed anyway as a result of natural processes (e.g., siltation, detrital transport, and anaerobic conditions). While creating a feeding area with optimal visibility may not be possible, simply increasing the size of the potential feeding area itself as well as the amount of potential food present resulting from increased fish habitat should be of significant benefit to the least terns.

121. Alternative 7. If only one least tern nesting area is established, a configuration for marsh restoration creating even more foraging channels can be proposed; Figure 13 illustrates such a proposal. High habitat diversity and interspersions are also achieved with this

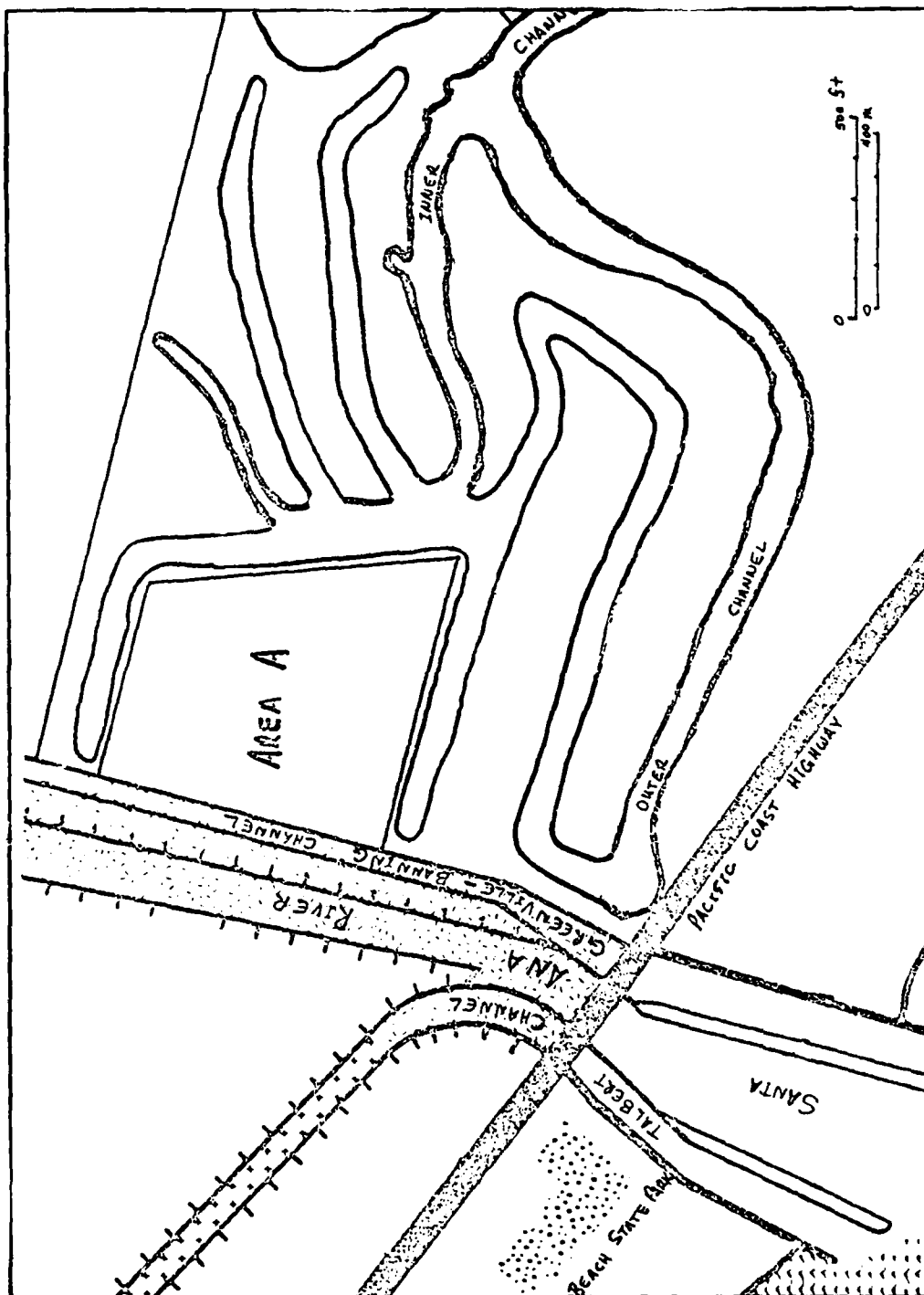


Figure 13. A configuration for habitat development providing one least tern nesting site (Area A) and additional east-west oriented tidal channels

alternative. Water surrounds nesting site A with the site graded so that the sand surface slopes gently to the water on three sides. This could provide a site for social flocking, pairing, mating, and bathing similar to that provided by the present sandbar at the mouth of the Santa Ana River (Collins et al. 1979:4). In the marsh restoration area, elevations could be established so that at least two elevation ranges are evident as described in the preceding example.

122. The seven alternatives presented here are intended to serve as conceptual models. The specific configurations may or may not be feasible based on the detailed information obtained during field and laboratory investigations. Based on the preliminary data provided for this report, however, restoration and development of the Santa Ana River marsh and associated habitat appear feasible.

Plant Propagation on the Site

123. Seven forms of propagules can be used for marsh vegetation establishment: seeds, rootstocks, rhizomes, tubers, cuttings, seedlings, and transplants (sprigs). Of these, transplants or sprigs are recommended as the propagule with the greatest potential for success.

Factors influencing planting design

124. The successful establishment of a planned marsh requires careful project design and implementation. Each site will exhibit its own peculiarities and must be approached individually. In any tidal salt marsh design, a number of factors are significant; the most important are discussed as follows:

- a. Salinity. In general, Pacific cordgrass will not tolerate conditions more saline than 35 ppt. Pickleweed and some of the other high marsh species can tolerate and will out-compete Pacific cordgrass should conditions become more saline at the correct elevation.
- b. Tidal range. Species should be planted that are adapted to the site specific tidal conditions. Pacific cordgrass grows primarily between MLW and MHW. It will integrate with pickleweed in the upper one-third of this

zone and between MHW and MHHW. Above MHHW, pickleweed can thrive at varying elevations above the littoral zone, depending on soil salinity and moisture.

- c. Flood stages. Seasonal or man-induced water level fluctuations in the river may desiccate or drown the plants or erode the site. The site will not remain viable if exposed to excessive periods of either flooding or drought (i.e., flooding sufficient to submerge the cordgrass throughout major portions of the growing season).
- d. Soil texture. If the soil texture is coarse sand and thus better drained, it may not be able to support adequate marsh plant growth or it may require fertilization; if it is of fine texture, it should support abundant plant growth without the aid of fertilizers.
- e. Wave and wind action. A stable substrate is necessary for successful plant establishment. High wind or wave energies are usually a hindrance to plant establishment and if they will occur, the site will require temporary protection until plants have been established.
- f. Contaminant tolerance. Should contaminants in the exposed substrate be found, potential for their release via marsh plant uptake and biomagnification should be considered (Environmental Laboratory 1978a:151).
- g. Outside influences. Outside influences such as animals grazing on transplants may create problems which could prevent successful establishment and should be considered.
- h. Costs. Depending on the specific site design selected, costs will increase with design complexity.

125. Protection. Physically, the site is well protected. However, young plants are particularly vulnerable to wildlife depredation. Herbivores such as geese, muskrats, nutria, rabbits, goats, sheep, and cattle, if present, can rapidly destroy newly established marsh (Smith 1978). Heavy grazing may even destroy mature marsh communities. Potential for animal depredation should be evaluated and in extreme cases should be controlled by trapping or fencing. In some cases, protection from excessive human use by posting or fencing is also necessary.

126. Plant spacing. In the Los Angeles region, Pacific cordgrass should provide cover relatively quickly if planted at 1-yd intervals using sprigs or transplants. Transplanted pickleweed sprigs should also be spaced at 1-yd intervals. If a nearby source of plant material

exists, pickleweed may be able to invade rapidly without assistance. However, it is likely that lowering the site elevation would remove all plants immediately available for colonization. If a seed source of annual pickleweed is present, rapid natural invasion of high marsh zones is likely by this species.

127. Diversity. In general, a site planted to a variety of species over a topographic range, from deepwater to upland areas, is preferred. Exceptions to this are sites where physical stresses are particularly harsh or stabilization is critical (as on steep slopes) where only one species can tolerate the conditions, or where quick cover by a vigorous monoplanting is needed. More typically, variation in site elevation with respect to tidal regime will necessitate planting the site with at least two species to obtain both high and low marsh (Environmental Laboratory 1978a:62).

128. Species diversity can be used to achieve several objectives:

- a. To appeal to a more diverse group of wildlife which may use the site.
- b. To enhance habitat for a target wildlife species that prefers mixed or patchy habitat for its life requirements.
- c. To control animal depredation by planting a high-value wildlife food species as a sacrifice.
- d. To better ensure site success; if one plant species does not become established, another one of the selected species may be successful and establish the habitat.
- e. To provide for long-range plant succession at the site by making available sources of several desirable species.

Specifically, in the case of the Santa Ana River site, plantings are intended to improve habitat for wildlife species which inhabit or frequent salt marshes and coastal habitats, particularly the California least tern, Belding's savannah sparrow, and the light-footed clapper rail.

Vegetation establishment

129. Plant species selection should involve consideration of the project goal, location, climate and microclimate of the area, species tolerance of environmental factors present, soil characteristics of the

site, species growth characteristics, availability, maintenance needs, and costs.

130. The plant species selected for propagation should be native species grown from available stock, onsite if possible, otherwise from as near a source as is available (coastal and not more than 100 miles distant) to ensure adaptability to site conditions. Pacific cordgrass and pickleweed are recommended because of their role as dominant species of California coastal marshes. Other high marsh plant species can be planted or may slowly invade the site naturally if a local source is nearby. These include mule fat, alkalai heath, saltgrass, shore grass, sea-blite, and ditch grass or widgeongrass. Planting details for Pacific cordgrass and pickleweed are included in Appendix C of Environmental Laboratory (1978a).

131. The growth characteristics of the species selected must be considered. Will the selected species successfully compete with other planted and naturally invading species, such as the possible competition already discussed between Pacific cordgrass and pickleweed? Will plant cover be established as rapidly as desired? If Pacific cordgrass is transplanted or sprigged on 1-yd centers, it should establish closed stands within 2-3 years. Pickleweed, because of its weedy nature, may invade rapidly on its own. If it is planted on 1-yd centers, it should establish closed stands in less than 2 years. Annual pickleweed will rapidly cover an area within 1 year if there is an ample seed source. Planted on 1-yd centers, both Pacific cordgrass and pickleweed should reach optimum size for reproduction in 3 years; they will spread vegetatively the first growing season. Both species should be capable of vegetatively maintaining viable populations and cover on the site once they are established. Both species will stabilize soils and aid in the prevention of onsite erosion. They are also relatively disease free and pest resistant.

132. Availability of selected species is crucial. Sources of Pacific cordgrass should be located. If an adequate source of sprigs is not available in the Santa Ana River marsh itself, nearby marshes must be found that are capable of donating adequate amounts of plant

propagules of an ecotype that is likely to be successful on the Santa Ana River site. The most efficient and cost-effective way to obtain and plant the propagules is by contracting to a commercial operation. Hiring a commercial firm to provide the plant stock and plant the site is recommended as a much more desirable alternative than attempting to do the work with the LAD manpower. Not only does use of an experienced, reputable firm increase the likelihood of success, but also, such firms usually guarantee their work for a period of time.

133. Careful, intensive, and frequent maintenance and management after initial site preparation and planting is costly and manpower-intensive. Species that are selected should be hardy and able to survive with minimal care. Pacific cordgrass and pickleweed are good choices, based on this criterion. Maintenance activities not considered excessive could include:

- a. Weeding or mowing undesirable competing species that invade the planted area in early stages.
- b. Postpropagation fertilization of the plant material.
- c. Protection by fencing and other barriers from wildlife grazers until establishment is ensured.

134. Species selection costs are generally lower if a commercial propagule source is located. Costs usually increase in proportion to the amount of hand labor required.

135. One should be aware of the pros and cons when selecting the type of vegetative propagule. Transplanting, while it is the lowest risk alternative in terms of quick, successful plant establishment is also the most expensive alternative. Seeding, conversely, carries the highest risk of successful establishment.

136. Optimum time for planting is in early or mid-spring. Since it will require one to two growing seasons to establish acceptable cover on the site, this should be taken into account when considering wildlife needs in the area during that period. Construction of the site should be planned to avoid breeding seasons of target avian species (e.g., during the period of October through January when the birds are not nesting); however, optimal time intervals for planting

are much more narrow. Fall planting is acceptable but involves more risk than spring planting since winter storms may wash out transplants before their root systems are established.

Pilot propagation study

137. A pilot propagation study is strongly recommended. The purpose of the pilot study is to determine whether or not the selected plant species will grow under conditions found on the site (Environmental Laboratory 1978a:76-77). Specifically, a pilot study one acre or greater in size will demonstrate the following: success of the selected species and suitability of the various propagule types available; problems that may be encountered with equipment or with grading the site; needs for fertilizer or lime and the appropriate rates of application; the best timing for plant establishment; the exact elevations for best growth; and both costs and time required for the operation which can be projected to the full-scale development. In addition, a successful pilot study is extremely useful in demonstrating that the concept can be applied successfully in the case of the given project and the specific site.

Soil bed preparation and treatment

138. Initial assessment of the new substrate should have revealed the following characteristics: texture, salinity, nutrient levels, and potentially toxic levels of metals, pesticides, petroleum products, and other contaminants. These must then be considered when preparing the soil bed and applying any treatments needed for planting such as liming and fertilizing. The actual plot preparation should take place just prior to planting of the site.

139. Grading. Based on the selected elevations and the trafficability of the soils present, the site must be graded to the desired elevations.

140. Fertilizer. Fine-textured soils tend to be rich in nutrients and probably will not require fertilizer. On DMRP dredged material habitat development sites, a positive short-term plant response generally was obtained by fertilizing sandy material although long-term survival of the sites were not affected by fertilizer application. As a

rule of thumb, fertilizer was considered a benefit only on sandy dredged material that required rapid and luxuriant cover for stabilization or that was not undergoing active accumulation of fine material. Soil testing should provide a clear indication of whether or not fertilizer is necessary on the Santa Ana River site.

Planting the site

141. As stressed earlier, vegetative propagules are recommended rather than seeds. Soil preparation is usually adequate on fine-textured materials as long as the bed is weed free, relatively clear of debris, and loose. The most common method of transplanting is by hand. If the site is trafficable, it may be possible to partially mechanize the operation. For example, the Salt Pond No. 3 Habitat Development Site in South San Francisco Bay was planted in part by hand from a tractor-drawn sled (Morris et al. 1978). As previously stated, spacing large transplants on 1-yd centers is recommended should provide coverage in 2-3 years. If very rapid cover is not a consideration and funds are limited, more distant spacing (2- to 3-yd centers) should result in full cover in 3 to 4 years, at a considerable savings in propagules, manpower, and costs. However, an increased erosion rate may result if distant spacing is used. If faster coverage is desired, propagules may be spaced as close as 0.3 yd.

142. Pickleweed and other herbaceous cuttings may be broadcast at the appropriate elevation and gently raked into the loose soil so that they are lightly and intermittently covered, then rolled to firm the surface. Should other species be desired at higher elevations, these can be established using agronomic upland practices set forth in Hunt et al. (1978) and in Coastal Zone Resources Division (1978).

Postpropagation maintenance and monitoring

143. There are two major considerations in postpropagation phases of any project: to maintain or not to maintain the site. Nonmaintenance has advantages of allowing natural succession to take place once the initial establishment is ensured and involves no additional expenditures. In the case of the Santa Ana River site, natural invasion of

desirable plant species is likely to be very slow. Disadvantages that could result from lack of maintenance are:

- a. Invasion by unwanted and undesirable plant species resulting in a major alteration in the site and its intended purpose.
- b. Colonization by undesirable wildlife species that may exclude species for which the site was originally intended.
- c. Major changes in topography such as unwanted breaches in dikes, severe storm damage, and erosion gullies. These should be repaired to prevent unwanted alteration of the site.

144. There are several reasons for monitoring a site and continuing site maintenance:

- a. To determine the need for further soil treatment, e.g., fertilizer application.
- b. To determine the need for replacement plantings or additional plantings.
- c. To determine the need for control measures for invertebrate and vertebrate pests, plant diseases, or invading plant species.
- d. To remove accumulations of litter or debris that might smother the plantings.
- e. To remedy erosion problems.

145. Once established, the Santa Ana marsh area will probably require little or no further maintenance. The least tern nesting area will require yearly maintenance to keep it free of vegetation.

Potential problems

146. Potential problems which will require additional scrutiny during detailed planning stages prior to construction include, but are not limited to the following points:

- a. Project timing. (1) Human activities should not occur during critical times of the life cycle of the California least tern as well as for other significant species that may be discovered using the area. (2) Predictable lead time is necessary to prepare plant propagules. (3) Planting is usually most successful if done in the spring.
- b. Contaminant uptake by plants. Contaminant uptake is not expected to be a problem. If laboratory analysis reveals high levels of contaminants, several techniques are available to assess the potential danger (Wolf et al. 1978,

Gambrell et al. 1978a). Overburden is being removed exposing new substrate; therefore, potential for undesirable concentrations of contaminants would seem low. Potential for contaminant uptake and transfer by plants should be considered. Studies by Gambrell et al. (1977 and 1977c), Khalid et al. (1977), Lee et al. (1976 and 1978), and Lunz (1978) indicated that contaminants are transferred from marsh soils to plants under conditions that are influenced by the characteristics of the contaminants, the plant species, and the physical and chemical properties of soil (especially moisture levels and oxygen in the soil). These factors should be evaluated based on the specific properties of the soils that will be exposed.

- c. Invasion of nonpreferred plant species. This is not expected if the recommended elevations are achieved. If the final elevation of the salt marsh is higher than that planned, plant species of a more upland character might invade. If the elevation is high, but tidal inundation still occurs, a high marsh might result when a low marsh was planned.
- d. Pests and diseases. Pest problems resulting from chewing by insects and snails; from grazing and trampling by wildlife and feral animals; or from predation on target avian wildlife species by free-ranging cats and dogs (Soots and Landin 1978) have caused occasional difficulties at habitat development projects and may be encountered at the Santa Ana River restoration site (e.g., a visiting flock of geese can very quickly decimate a field of tender, young transplants). Such problems should be rectified, if necessary, as they occur. Garbisch (1977) lists suggestions on pest control. While plant diseases do occur among marsh species, healthy stands will generally not become heavily infected. Only in cases of severe infections should control measures be undertaken.
- e. Quality control during grading and elevation adjustment is crucial. Because of the critical elevation tolerances involved, careful supervision of the grading operations is necessary. Small errors during this stage of the project may significantly alter the desired results or cause the project to fail.

Costs

147. The costs of planning, constructing, and propagating a site are based on the many considerations discussed in previous sections of

this report. Costs of the project are determined from decisions regarding these considerations and the site specific project goals. Each of the six DMRP marsh development sites varied considerably in cost, reflecting the various specificities and research demands encountered. They are referenced in the following to provide background and, perhaps, some basis for comparison.

Planning

148. Planning costs involve site selection, site characterization, planning design and engineering, and coordination. In a comparison of two DMRP field sites, planning and engineering design costs were \$45,000 at Bolivar Peninsula and \$35,000 at Windmill Point. Both of these sites are approximately 8 ha in size in comparison to approximately 30 ha at the Santa Ana River site. Note, however, that the planning and engineering costs of the DMRP projects were increased by detailed research aspects and difficult site problems. More conventional marsh development sites should have substantially lower planning costs.

Construction

149. Construction costs vary greatly and are influenced by such variables as access to the site, distance between the dredging and disposal sites, dredged material and foundation characteristics, energy regimes, cost of protective and other structures, availability of equipment, and local labor rates. Most of the construction costs encountered in marsh development are associated with conventional methods of confined dredged material disposal. In the case of the Santa Ana River project, disposal of excess material may prove difficult and costly. Special costs associated with habitat development in this case will include fencing and elevation adjustments. Construction costs exclusive of actual dredging were \$228,000 at Bolivar Peninsula and \$167,500 at Windmill Point. These totals include dike construction and maintenance, postconstruction grading and elevational changes, and other site preparation measures. The reason for the substantial cost difference is primarily the result of use of a more expensive protective structure (large fabric sand bags) at Bolivar Peninsula. A temporary sand dike was employed at Windmill Point. Cost estimates for

rehabilitation of the Santa Ana River marsh will depend greatly on the design alternative selected, and the volumes of material and distances it must be moved.

Propagation

150. Dollar figures and estimated times for planting have been given by several investigators (Dodd and Webb 1975, Garbisch et al. 1975, Knutson 1977, Morris et al. 1978, Ternyik 1978, Woodhouse et al. 1972 and 1974, and Zarudsky 1975). Because of regional differences, plant species selected, collection and planting techniques, skill of personnel, and other factors, these costs varied greatly. The transplant figures presented are expressed in cost per hectare, assuming that plants were established on 1-yd centers (4000 plants/acre). Depending upon project objectives, cover could be obtained by more or less intensive plantings. A 0.5-yd spacing would require 16,000 plants/acre; 2-yd spacing would require 2000 plants/acre. It is advisable to obtain more propagules than estimated in case of propagule loss, death of some plants, or the site being constructed at a different elevation than planned.

151. Woodhouse et al. (1972) found that collecting and transplanting smooth cordgrass by hand on 1-yd centers required 54 man-hours/acre on sandy dredged material in North Carolina. They also experimented with smooth cordgrass seeds and found harvest more efficient by machine than by hand. In general, they and Garbisch et al. (1975) found that seeds are an economical propagule type for sandy substrates on the east coast, but this propagule has the least successful establishment rate (Environmental Laboratory 1978a).

152. Dodd and Webb (1975) compiled data from their research on the Texas coast, showing man-hours/1000 plants required to hand dig, separate, and transplant various propagule types of 11 marsh species. Variations in man-hours resulted when difficulties were encountered in separating clumps or digging dense, stout root systems. These figures range from 11.3 to 29.3 man-hours/1000 acres and are probably applicable to the proposed work at the Santa Ana River site.

153. Planting of the Miller Sands marsh site in the Columbia River, which was composed of sandy dredged material, is described in Ternyik (1978). Ternyik encountered only minimal difficulty in obtaining and separating material. Tufted hairgrass transplants required 35 man-hours/acre for digging and planting, the least manpower required for any species planted at Miller Sands. Lower manpower efforts at this site compared with other sites discussed above are probably reflections of a professional nursery work force, highly skilled in transplanting techniques.

154. Marsh propagation costs will be extremely site specific and will reflect such factors as logistics, man-hour costs and efficiency, planting design, and the texture of the substrate. The data presented here (Environmental Laboratory 1978a) are developed from sites that could support conventional equipment. Should the substrate of the site be poorly consolidated fine-textured material, more man-hours will be required to propagate due to trafficability problems.

155. As a general rule, man-hour efforts should range from:

- a. 40 to 80 man-hours/acre for transplants and sprigs.
- b. 40 to 60 man-hours/acre for rhizomes, tubers, and root-stocks.
- c. 4 to 16 man-hours/acre for seeds.

The above figures are for labor only and may be used to calculate costs of the propagation effort based on current labor wages.

156. Equipment and supply costs are indicated below, and are estimates in 1978 prices:

- a. Bulldozer for elevational adjustments and transplant bed preparation--\$30 to \$75/hr.
- b. Tractor and disk for seedbed preparation (coarse-grained material only)--\$4 to \$14/acre per trip over the site, \$8 to \$28/acre for double cutting.
- c. Fertilizer. All purpose 13-13-13 (N-P-K)--\$6/100 lb.
- d. Plants from commercial source. Marsh transplants may be obtained from a few commercial firms at costs ranging from \$0.14 to \$0.75 per plant, and seeds of some species may be available. Consult a local source for these propagules. A list of commercial and government sources of upland propagules is given in Hunt et al. (1978); many

of these firms will supply limited marsh propagules as well. DMRP commercial sources included Wave Beach Grass Nursery, Florence, Oregon; Environmental Concern, Inc., St. Michaels, Maryland; and San Francisco Bay Marine Research Center, San Bruno, California.

PART IV: BRUNSWICK, GEORGIA, HARBOR DEEPENING PROJECT: HABITAT
DEVELOPMENT AND MARSH VALUATION

by

M. C. Landin

Introduction

157. In response to a request by the Savannah District (SD) to the DOTS for assistance with habitat development at the Stage 2 Scoping Meeting on the Brunswick Harbor Deepening Project, the following comments and discussion are offered.

158. The draft project plans are in Planning, Stage 2, and the first public comments have been received. The Scoping Meeting was held to determine which of five proposed disposal plans formulate the best alternatives for the project and that have the most acceptance among the various State and Federal agencies and private groups concerned.

159. All five plans make varying use of 19 proposed or presently used disposal sites along the shorelines, beaches, and marshes of Brunswick Harbor or on diked upland sites (U. S. Army Engineer District, Savannah 1979). In addition, one more site has been proposed by Georgia Department of Natural Resources (DNR). The plans range from the least cost and engineering ease of Plan I to more environmentally pleasing considerations involving more cost in Plan V.

160. Marsh development feasibility and techniques will be discussed in this report on a site by site (Site A-Site P as shown in Figure 14) basis for ease of use by the SD personnel. Marsh values are considered preliminary and valuable to the cost ratio of the project by the SD, so separate comments devoted to this subject are brought out in the following section.

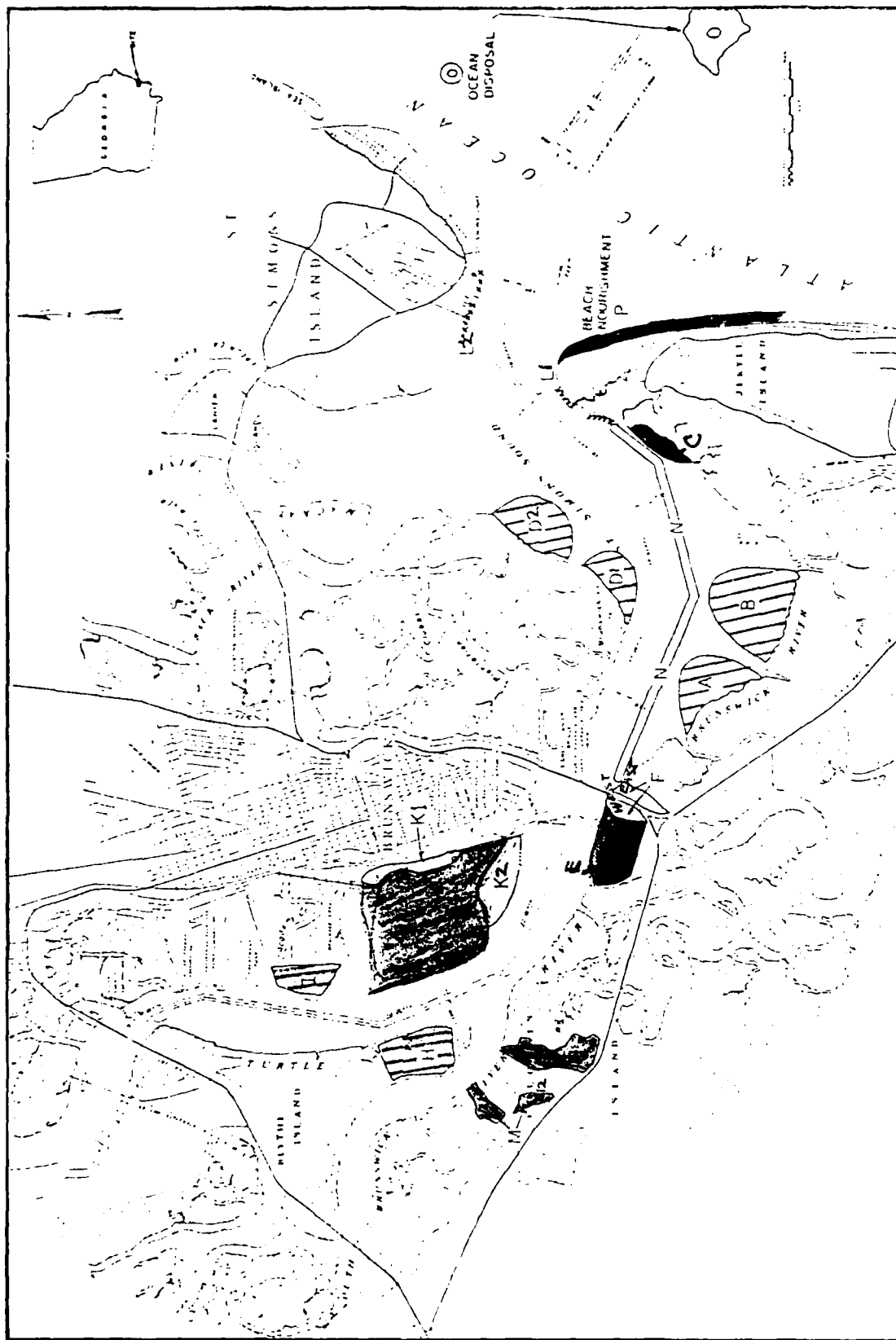







Figure 14. Overview sketch of the 19 disposal sites under consideration in the Brunswick Harbor Deepening Project. Marsh development = ; seabird development = ; multiple use = ; industrial/recreational use = ; sites no longer under consideration = 

The Value of a Salt Marsh

161. As early as the last century some Americans have recognized that marshes were productive wildlife and fishery areas and that they should be considered valuable as such. Voisca (1928) pointed out in an early paper to the Ecological Society of America that man-made changes in the marshes in his home state of Louisiana were having very significant impacts on the marshes. He named building of flood control structures, clearing and draining for agricultural use, and harvesting timber by lumber industries as the "land use culprits" that eliminated marshes. He made no attempt to place dollar values on marsh lands.

162. Following that time, salt marshes began to have limited recognition as important valuable resources in various references. However, many more people were finding salt marshes "productive" from their own points of view only when they were diked, filled, and built upon (Galloway 1978).

163. The first real attempt to place dollar values on salt marshes occurred in the 1970s when Gosselink, Odum, and Pope (1973, 1974) attempted to convert traditionally and previously unconsidered values of a salt marsh into dollar figures. They have said that they attempted this difficult and controversial task in response to the great need for this kind of information. Their intent was that if a dollar value could be achieved, it would be easier to answer critics of marsh land conservation and/or management who called marsh land of little worth or of lower value than if developed into areas for direct human use (commercial, residential, or agricultural).

164. Gosselink, Odum, and Pope (1973, 1974) pointed out that various researchers (Burrows in Coates 1972, Carley 1968, Dolan et al. 1973, Grant and Patrick 1970, Hoyt 1967, McHugh 1966, E. P. Odum 1968 and 1971, H. T. Odum 1971, W. E. Odum 1970, Odum and de la Cruz 1967, Odum and Fanning 1973, Odum and Odum 1972, Pope 1972, Stowe et al. 1971, Teal 1962, and Valiela and Teal 1972) have shown values of marsh lands, each from their particular area of expertise. Economic benefits could come from a wide variety of approaches and marsh uses. Gosselink,

Odum, and Pope (1973, 1974) estimated dollar values for an acre of (fresh and salt) marsh land in three major categories: commercial and sports fisheries, aquaculture, and waste treatment. There are many considerations for which they did not make dollar value estimates. Nonconsumptive uses of marshes such as bird watching and esthetic values; consumptive values such as waterfowl and rail hunting; trapping of marsh fur-bearing animals like muskrats, nutria, otters, and beavers (fresh marshes); selective harvesting of alligators, turtles, and snakes (fresh marshes); protection as buffers for the upland areas from storm tides and harsh coastal conditions; harvesting of mature marsh grass stems for construction of baskets, chairs, and other utility and tourist items; and numerous other miscellaneous, but significant values of marsh lands were either mentioned (but no dollar values calculated) or not considered.

165. Gosselink, Odum, and Pope's (1973, 1974) estimates ranged from \$52,000 per acre for a moderately used level of high marsh to \$83,000 per acre for highly productive tidal salt marsh. These estimates were made in 1973; given an average inflation rate of land value of 10 percent annually, these estimates must be scaled upwards from \$94,070 for high marsh to \$147,000 for low marsh (calculated to 1979). When it is remembered that many marsh uses are not included in these figures, it seems very likely that actual dollar value for an acre of productive marsh would be in excess of the above figures.

166. After publication of Gosselink, Odum, and Pope (1974), several agricultural economists took exception to their estimates and published a rebuttal based on existing agricultural land values and their view of the methods of calculation used for the Gosselink paper (Shabman and Batie 1976). E. P. Odum (1978) and H. T. Odum (1978) published responses to the rebuttal and since that time a rebuttal of the response to the rebuttal of the original paper has been made (Shabman and Batie 1979), and so the evaluation process moves on. Based on several factors, including marsh experience, efforts to prove their calculations, and knowledge of the professional integrity and competence of the three authors, there is no apparent reason to fault them in their

estimates other than their failure to reach dollar figures on items discussed in paragraph 164, which would have increased the estimates

167. One other factor not previously considered will also have an impact on marsh values. Gucinski (1978) determined that small marsh tracts were more valuable than large marsh tracts due to the well-known ecological principle of edge effect. The greater the amount of edge, the greater the access to fry and other organisms for nurseries, and the greater the flushing action of the marsh, which increases net productivity of that marsh. According to Gucinski (1978), smaller tracts also seemed to have greater appeal and use by certain wildlife such as waterfowl, marsh mammals, and waterbirds.

168. The whole concept of placing dollar values on undeveloped natural marsh is new and not widely accepted by more conventional economists (E. P. Odum 1978). Any use of the figures quoted in this report should be approached with that knowledge.

Feasibility of Salt Marsh Development

169. Marsh development has been accomplished in increasing numbers of projects and acreages throughout the United States over the past several years. It has been demonstrated as a feasible habitat development alternative using dredged material substrates by the DMRP at sites in Oregon, California, Georgia, Florida, Virginia, and Texas (Smith 1978).

170. Marsh development in Georgia consisted of grading an existing sandy dredged material deposit to an intertidal elevation, fertilizing, and planting it with coastal salt marsh grasses and shrubs (Reimold et al. 1978b). The site is located at Buttermilk Sound in the Altamaha River estuary. The project yielded much useful data on various so-called "minor" marsh species as well as the major Georgia coastal marsh colonizers smooth cordgrass and saltmeadow cordgrass. The site has been successfully vegetated; it is presently thriving and shows increasing wildlife use.

171. While marsh development as a disposal alternative is

definitely feasible for the Georgia coast, three major topics often arise in any discussion of building marshes in Georgia:

- a. Many Georgians feel they have enough marshes.
- b. Disposal sites on or around existing marshes are very difficult to locate.
- c. Marsh development is more costly when compared to alternatives that don't involve marsh development.

172. The thought that Georgia has enough marshes is reflected in the attitude and approach to dredging operation plans by the DNR. They have on numerous occasions stated this. They have, however, in recent months talked about possibilities for building marshes on sites where erosion has destroyed or seriously affected an existing marsh. This option is under consideration for the Brunswick Harbor project.

Disposal Sites

173. The Brunswick project has 19 disposal sites under official consideration. In addition, another site has been proposed by the DNR. The 17 Oct 79 Scoping Meeting between the SD and other agencies and groups resulted in the dismissal from immediate consideration of Sites A, B, D1, D2, H, and I. Site O was intended solely for disposal of end-of-channel material at sea. Sites L1 and L2 were considered for possible disposal of bedrock material and some sand. Site P was considered solely for sand beach nourishment for recreational use, and P receives such heavy human use that no consideration for wildlife could or would be made at that site.

174. Sites M1, M2, and G were considered solely for upland disposal on property owned by the State of Georgia for industrial and port development. The only sites remaining for any consideration of habitat development were C, F-east, F-west, E, K1, and K2, although based on experience and knowledge of seabird biology, the author feels that sites L1, L2, and P will receive heavy seabird resting use with possible attempts to nest in spite of expected heavy human use of those sites (Landin 1978b).

Habitat Development

175. Two different habitats are under consideration. Salt marsh habitat development is possible on parts of Sites C, E, F-west, K2, and the proposed new site; colonial seabird habitat development is possible on Sites F-east, K1, and K2. In addition, Site F-west is tentatively planned for a boat launching ramp/recreational site, Site F-east for a construction fill material depository, and Site K2 for long-range port facility construction.

Marsh habitat development

176. Site C. This site is a small one between the interior marsh and the shipping channel west of Jekyll Island. Overboard open water disposal was intended for this site and would lend itself to establishing a suitable intertidal substrate for marsh development if the material was coarse grained rather than fine. Fine material would require a temporary or permanent dike to maintain acceptable water quality in the area. Because of the nearness of the shipping channel and the northwest fetch across St. Simons Sound, this area would require immediate planting of smooth cordgrass to stabilize it as rapidly as possible, and probably a temporary stabilizing dike as well.

177. Site E. This site already contains approximately 140 acres of intact salt marsh and small potholes in the marsh back from the Brunswick Harbor waterway. These potholes receive waterfowl use for feeding and resting (Figure 15). Historically, the outer edge of the marsh extended further into the waterway, but has eroded away. This eroded area is suitable for disposal of some of the dredged material from the adjacent channel and proposed turning basin. Enough dredged material to have a final intertidal elevation no greater than the existing adjacent salt marsh could be placed there. A final elevation higher than the existing marsh would result in (a) the formation of a high marsh in front of the original marsh, (b) the degradation of the original marsh because tidal flow was eliminated or severely reduced, and (c) severe negative impacts on the planned habitat development of the site.

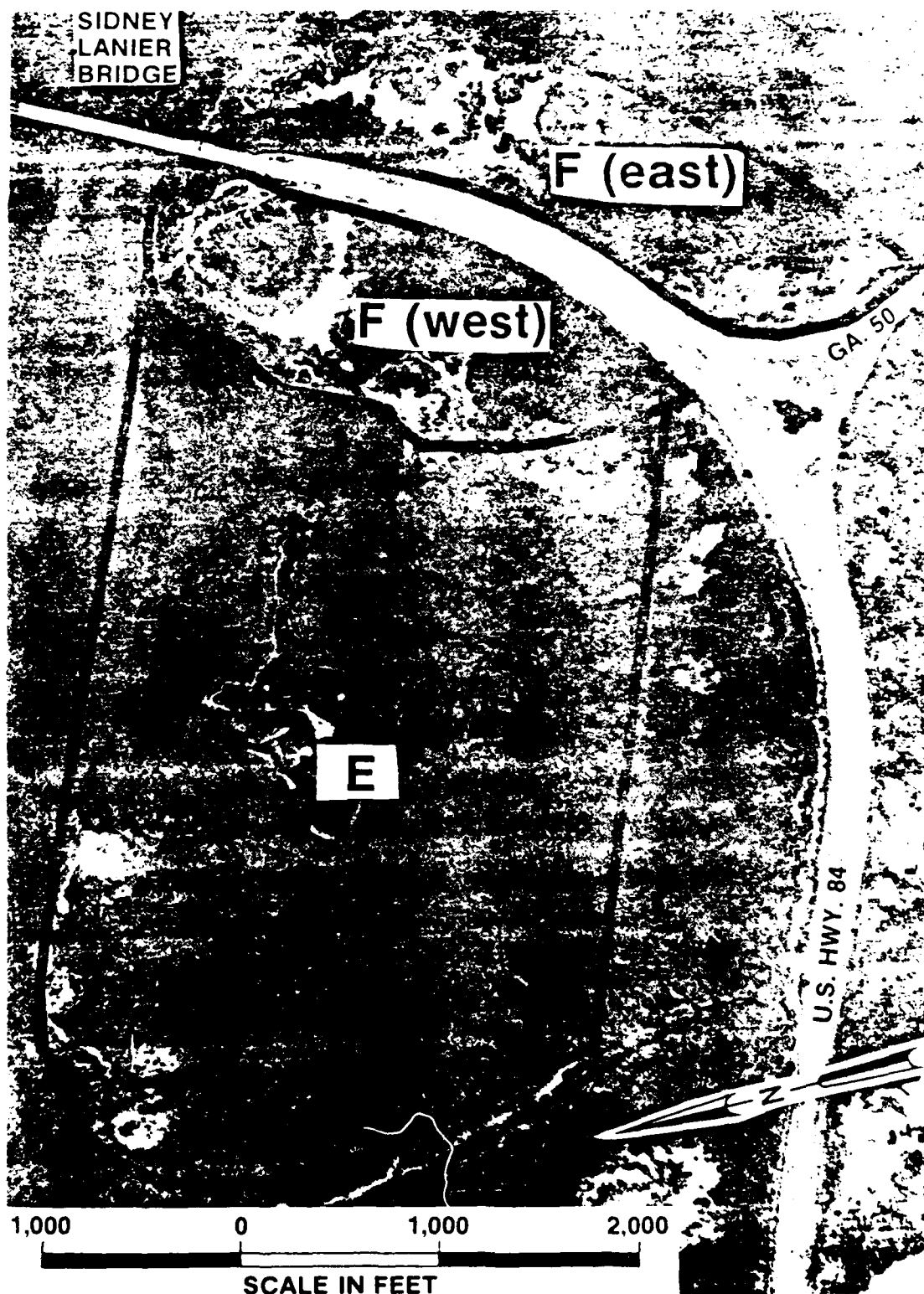


Figure 15. Aerial photograph showing Sites E, F-east, and F-west for the Brunswick Harbor Deepening Project

178. The interior potholes and the existing marsh area in Site E would remain undisturbed and would continue to be productive marsh and waterfowl areas.

179. Site F-west. This site already contains one or more old deposits of dredged material. It is immediately adjacent on the east to Sidney Lanier Bridge and is fringed on its western side by the salt marsh of Site E (Figure 15). This site appears to have already been impacted by bridge construction and/or deposition of channel dredged material. The high spots of dredged material are vegetated with coastal maritime shrubbery and herbaceous plants.

180. Since the site will be used for the construction of a parking/recreation/boat launching facility, any marsh or other type habitat development is precluded. However, were that intended land use to change, dredged material could be placed along the outside of the existing marsh fringe at an intertidal elevation as a continuation of Site E.

181. Site K2. This site is immediately outside the Andrews Island dike, south of the island (Figure 16). It includes approximately 50 acres of salt marsh and maritime herbaceous and shrubbery vegetation and has the potential of a multiple-use complex. If the site is developed based on present plans for disposal, a dike will be built which will inclose the 50 acres of land and 130 acres of water surface area. This site is presently planned for upland disposal and the Brunswick Port Authority views Site K2 as an ideal location for an expansion of port facilities.

182. There are two wildlife uses that could be made of this site as well: marsh development or seabird nesting. Seabird use is discussed in paragraph 200. Marsh development can only be carried out if the dike to be constructed is temporary or, in case of sand dredged material, no dike is built. A dike such as that envisioned for the site for upland use would prevent tidal flow completely and destroy rather than create marsh.

183. Dredged material, primarily from the turning basin, placed at the proper intertidal elevation south of the existing salt marsh

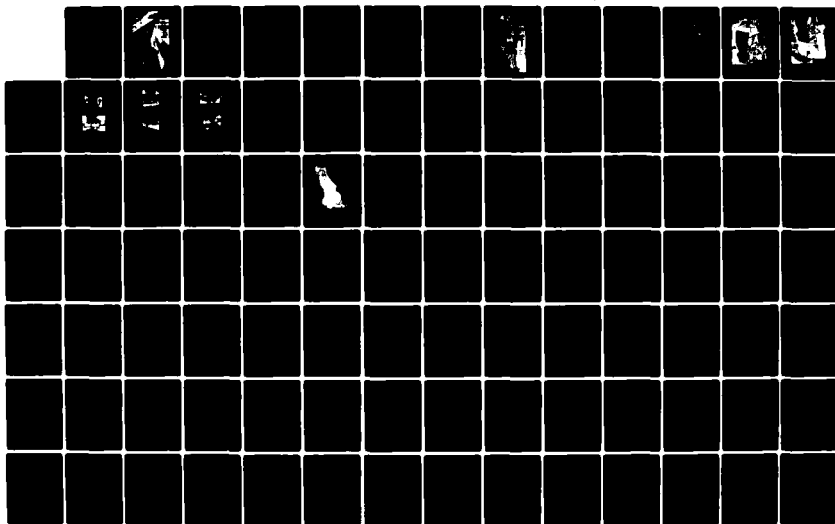
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FEASIBILITY AND ASSESSMENT(U) ARMY ENGINEER WATERWAYS
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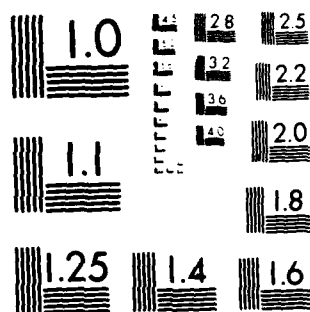
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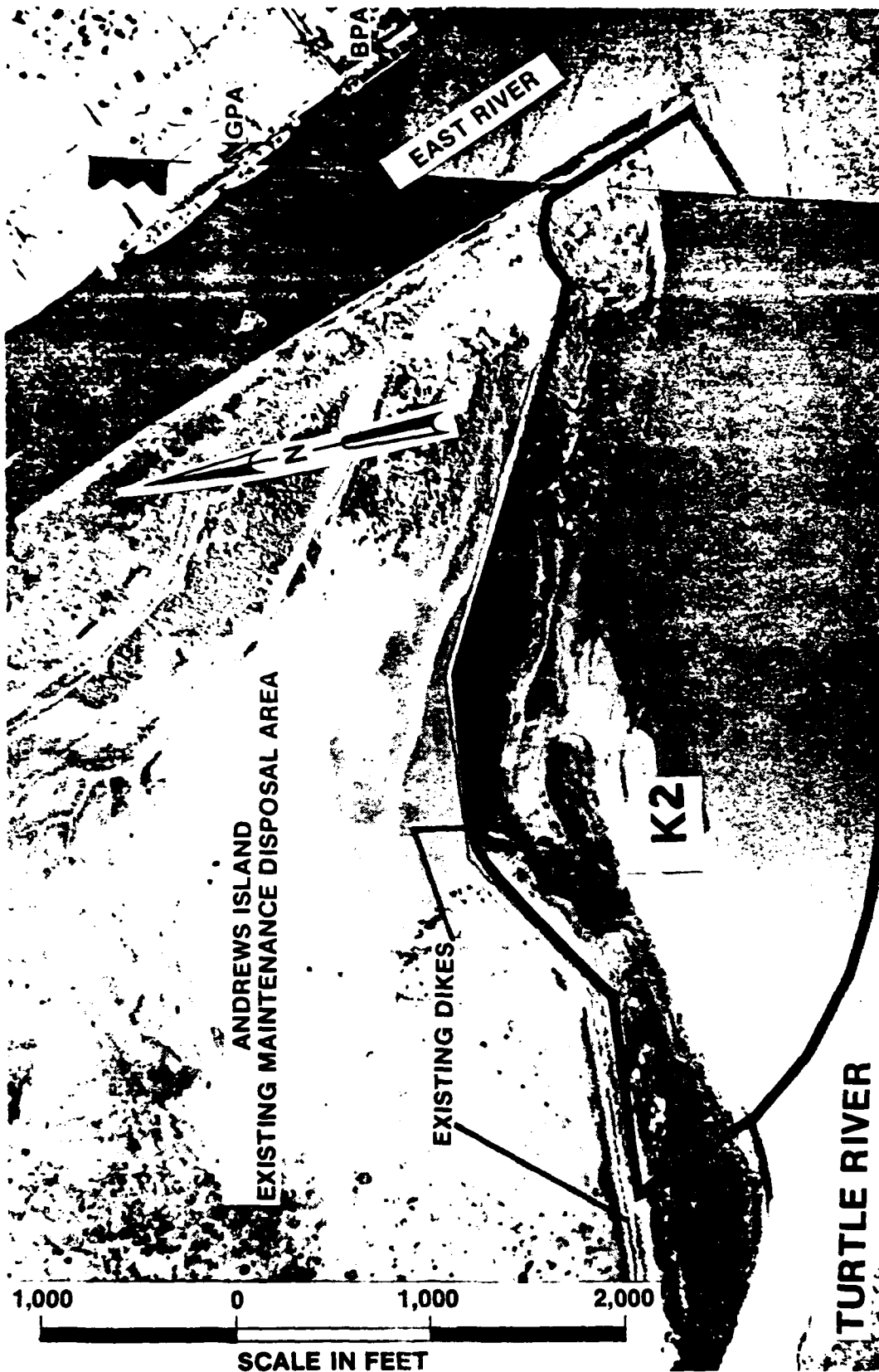


Figure 16. Aerial photograph showing Site K2 for the Brunswick Harbor Deepening Project

would serve as substrate for a new marsh of approximately 100-130 acres. The new marsh probably will require planting if (a) it is somewhat protected from waves and ship traffic wakes and (b) it has a readily available propagule source of smooth cordgrass.

184. If stability is a problem, a temporary sandbag dike may be necessary to prevent erosion of the substrate while smooth cordgrass sprigs are transplanted to the site. This should occur as soon as possible after the site is trafficable for maximum stability and first year growth. Techniques, sources, and planning procedures for marsh development of all mentioned sites are set forth in Environmental Laboratory (1978a) and Landin (1978a).

185. A multi-use plan for Site K2 could easily be developed, especially in conjunction with Sites K1 and F-east, and will be discussed later.

186. Jekyll Island Site. The DNR suggested after the 17 October 1979 Scoping Meeting that another potential disposal site exists on Jekyll Island. The site was dug out for borrow material for Jekyll Island airport construction. A "hole" in the marsh approximately 30 ft deep was formed. The DNR suggests filling this area with dredged material back to an intertidal elevation and letting it develop as salt marsh.

187. The site has not been examined by the SD to determine its potential use nor its present use to area wildlife. However, it will be considered for possible disposal from the "N" section of the Brunswick Shipping Channel (Figure 14).

Colonial seabird habitat development

188. Historically, seabirds who required bare ground habitat for nesting found this habitat on Atlantic coastal barrier islands. These areas have been almost entirely taken for human recreational, residential, and industrial use. The seabirds have resorted in increasing numbers to using bare or partially vegetated dredged material deposits, especially islands, for nesting because these areas mostly remained free from predators and humans. The seacoast of Georgia is no exception. Black-necked stilts, least terns, royal terns, black skimmers,

laughing gulls, and other seabirds nest on bare or slightly vegetated dredged material islands or deposits, or on isolated beaches. These species should readily adapt to using dredged material deposits in Brunswick Harbor and other sites on the Atlantic coast if habitat and protection are provided. Species use has been documented by numerous researchers over a period of years (Landin 1978c). Personal communication with Mr. R. R. Lewis, III of Mangrove Systems, Tampa, Florida, Messrs. John Ogden and Herbert Kale of the National Audubon Society, and biologists in the SD have pointed out the availability of breeding aged adult seabirds that could colonize any bare ground, protected habitats which were provided.

189. The Office, Chief of Engineers (OCE), is aware of the critical waterbird nesting habitat that is provided by the Corps of Engineers through their dredging activities. According to the SD, a letter directive instructing all Districts to include, or at least consider feasibility of, habitat development for colonial waterbirds in dredging projects has been issued by OCE in recent months.

190. Site F-east. This site is located adjacent to the Sidney Lanier Bridge on the west with salt marsh bordering it on the east. It has large patches of bare areas which may be of dredged material origin but most likely are fill material from construction of the bridge (Figure 15). The site contains some marsh and upland maritime vegetation, but the whole site appears to have been impacted by the bridge construction activity.

191. This site has been suggested for a depository of dewatered dredged material that can be removed by the Georgia Department of Highways for road construction use. It also allows vehicular passage from Site F-east to Site F-west under the Sidney Lanier Bridge, which puts it into consideration for an access road from the northbound traffic lane to the planned boat launching ramp/recreational area at Site F-west.

192. Since dredged material from the shipping channel may be stockpiled at this site and the material will primarily consist of sand, a plan for providing bare ground nesting habitat for seabirds can

easily be carried out on this site. There are numerous reasons this site is ideal:

- a. The dredged material will be sand and shell, the best substrate for seabird nesting (Soots and Landin 1978).
- b. The Georgia Department of Highways may be providing on a consistent basis newly exposed bare sand areas through removal of fill material. This will make removal of vegetation from the nesting site easier or unnecessary (Landin 1979).
- c. The stockpiled dewatered material will be of sufficient elevation to prevent flooding of nests by storm tides (Soots and Landin 1978).
- d. There will be no dike to prevent access to water of the seabird chicks (Parnell et al. 1978, Landin 1979).
- e. Feeding areas for fish-eating terns and skimmers are nearby and abundant.
- f. The Sidney Lanier Bridge offers no access to the site. If an access road is built to Site F-west, the erection of a stout fence and posting would effectively prevent nesting colony intrusion by curious humans.
- g. The Georgia Department of Highways is considering their role in this habitat development effort. They seem willing to abide by known management techniques (Soots and Landin 1978; Landin 1979) for seabirds, and to use their equipment to provide bare ground sloped areas preferred by these species inside a protective fence.

193. There are several disadvantages if a large colony becomes established here:

- a. The effects will be temporary for an unknown number of years (until all fill material has been removed).
- b. There is no source of new sandy dredged material for replenishment of the site since future maintenance dredged material will generally consist of silt. Silt can and will be used by seabirds for nesting (Scharf et al. 1978, Parnell et al. 1978), but this is not the preferred substrate.
- c. Curious humans, in spite of a fence, may aggravate the nesting birds and cause loss of young.
- d. Predators, especially avian predators such as laughing gulls and night herons, may cause colony damage. If the fence does not totally surround the colony, depredation by raccoons, foxes, and feral dogs and cats may become a problem.

194. The erection of a fence around the entire site, or at least around the deposit of dredged material, is considered essential to the success of the habitat development. The removal of vegetation colonizing the deposit is also essential, whether by highway department equipment during routine work or by scheduled maintenance by concerned biologists.

195. Cooperation from the Georgia Department of Highways is essential for habitat success. Their workers must be constantly alert during the nesting season (April-August) for colony activities and carefully avoid these areas. A few humans working in an area can totally destroy a colony simply by keeping birds from their nests in the heat of the day. Eggs, embryos, and young chicks exposed to the summer sun can die with less than 5 min exposure depending upon the day's temperature (Soots and Landin 1978).

196. The highway department can:

- a. Provide a newly exposed bare substrate each spring before 15 April.
- b. Keep their workers off the exposed site until at least June to give seabirds a chance to use the site. By June, if no colonization has taken place, the birds will have set up colonies elsewhere that year.
- c. Have their workers alert for any colonization at any time during the nesting season, since birds may be forced out of another colony by storm tides, human disturbance, or other causes. In such cases, colonization attempts will be made at new sites, especially by least terns and black skimmers.

Skimmers and least terns renest up to 3 to 4 times due to disturbances each year until they find a successful colony site. Habitat for these two species, as well as for royal terns, Sandwich terns, and Caspian terns is considered critical along the entire mid, south, and Gulf coasts.

197. Since there are numerous breeding-age seabird adults using the Brunswick Harbor for nesting and feeding, nesting colonization is very likely to occur on any protected site although there is no way to guarantee that this will happen.

198. Site K1. This site is located on Andrews Island across the channel from the city of Brunswick and it is already an upland site (Figure 17). Its only present use is by fishermen who cross over to Andrews Island and by seabirds loafing on the site. Dredged material could be placed in this site to almost any reasonable elevation from an engineering standpoint and seabirds would continue to use the site. The adjacent channel and rivers offer good feeding areas. If protection and bare ground spots were maintained on Site K1, seabirds should nest on the site.

199. The best protection is fencing and posting. However, limited access to the island gives some protection at the present time. If the Brunswick Port Authority develops Site K2 into greater port facilities, the only way Site K1 would remain of benefit to seabirds would be through posting and fencing protection. A good access road built to the island would greatly decrease its value to seabirds.

200. The City of Brunswick might consider the tourist potential involved with having a seabird colony on its waterfront. Cities in other Atlantic coast areas have effectively capitalized on their sea and wading bird colonies by (a) protecting the colonies, while (b) building viewing platforms and touting the colonies as part of their tourist package (Buckley and McCaffrey 1978, Soots and Landin 1978).

201. Site K2. This site was discussed in paragraph 181 as a possible marsh development site and being slated by Brunswick Port Authority for eventual development as port facilities. If a decision is made to exclude marsh development as a site alternative, the resultant upland site built by the filling of the planned dike with dredged material would offer a good site for seabird use. They will undoubtedly rest there since they already use Site K1 for this purpose. If portions of the site were graded or plowed yearly to maintain bare ground areas, with adequate protection, seabirds should nest there. An island the size of Andrews Island is not the usual site selected by seabirds for nesting. However, the selection criterion for seabird species seems to not be based on size, but protection from intrusion by humans and other predators (Soots and Landin 1978).

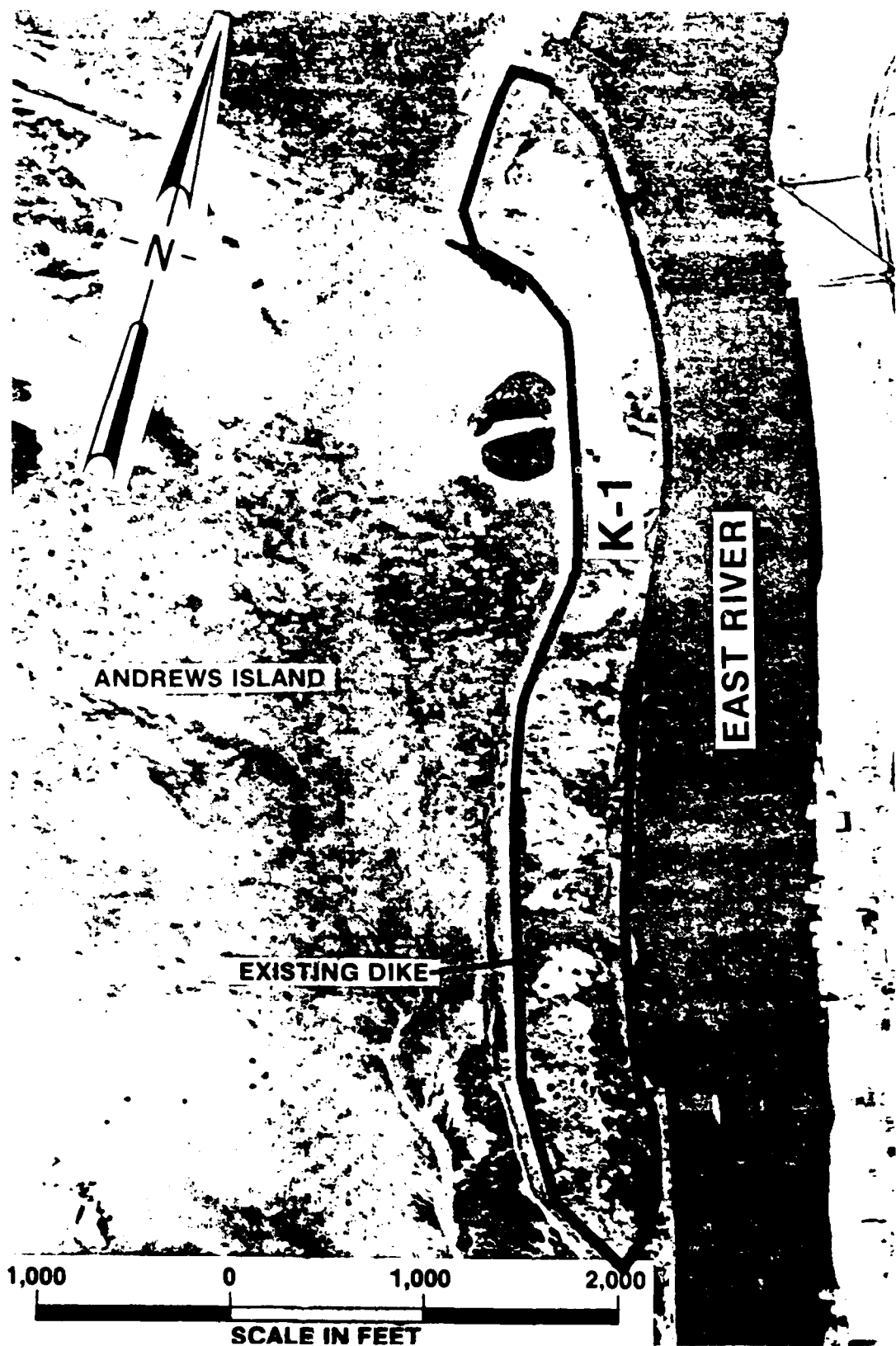


Figure 17. Aerial photograph showing Site K1 for the Brunswick Harbor Deepening Project

202. Even if Brunswick Port Authority has planned the site for eventual use, it can effectively serve as temporary seabird habitat until such time as this port development occurs. If the site becomes intensively used by seabirds, when it is developed, provisions should be made to continue to provide fenced colony sites. Once again, although the primary biological goal is to offer needed nesting habitat to seabirds, the city could use the colonies as tourist attractions through proper protection and observation platforms. Seabirds will become accustomed to humans near their nest sites as long as the birds' territories are not violated (Soots and Landin 1978).

203. Other sites. There are numerous other sites in Brunswick Harbor and along the Georgia coast that would be suitable for seabird colonies with a minimum of correct wildlife management. Although these sites are not within the scope of this project, the SD may possibly want to consider this habitat development alternative in other District areas.

Summary

204. A general overview of marsh values, feasibility of marsh development, marsh development potential, and colonial seabird habitat development potential has been presented. If more information is needed by the SD, this information is available from the DOTS team in greater detail. There are numerous examples of successes where marsh development and seabird colonization have occurred that may be presented if needed by the SD in the development of not only the Brunswick Harbor Deepening Project, but the other projects on which the SD has requested DOTS assistance.

PART V: RESTORATION OF WETLANDS HABITAT ON GIFFORD-HILL MINING
COMPANY LANDS IN NORTHWESTERN LOUISIANA

by

M. C. Landin

Preliminary Assessment

205. The DOTS was asked to assist New Orleans District (NOD) in the preparation of a restoration plan for a destroyed cypress/bottom-land hardwood area in northwestern Louisiana. The area has been strip-mined for a period of years by Gifford-Hill Mining Company of Sibley, Louisiana. The company has been operating without a permit, and the NOD issued a cease-and-desist order to prevent more wetlands destruction that had already taken place. The NOD was made aware of the problem via a private citizen letter less than a year ago. This report was prepared to provide recommendations and guidelines for restoring various wetlands habitats in strip-mined areas throughout the NOD and specifically for the Gifford-Hill mine site.

206. Preliminary project assessment has shown that while both Gifford-Hill and other area mining operations (smaller companies) have strip-mined an area covering almost five square miles (Figure 18), mandatory restoration is only necessary in an area of not quite one square mile of wetlands (Figures 18, 19, and 20) because it was mined after 1977 and is covered by recent wetlands permitting regulations.

207. Even though the present appearance of the strip-mined area offers a highly disturbed picture of the former habitat, it definitely is feasible and possible to restore this area to useful wetlands habitat. A potential conflict arises in that, upon consultation with U. S. Fish and Wildlife Service representatives, they have indicated that they prefer bottomland hardwood habitat development in the area; the Louisiana Game and Fish Commission prefers to see the area developed primarily for sportfishing.

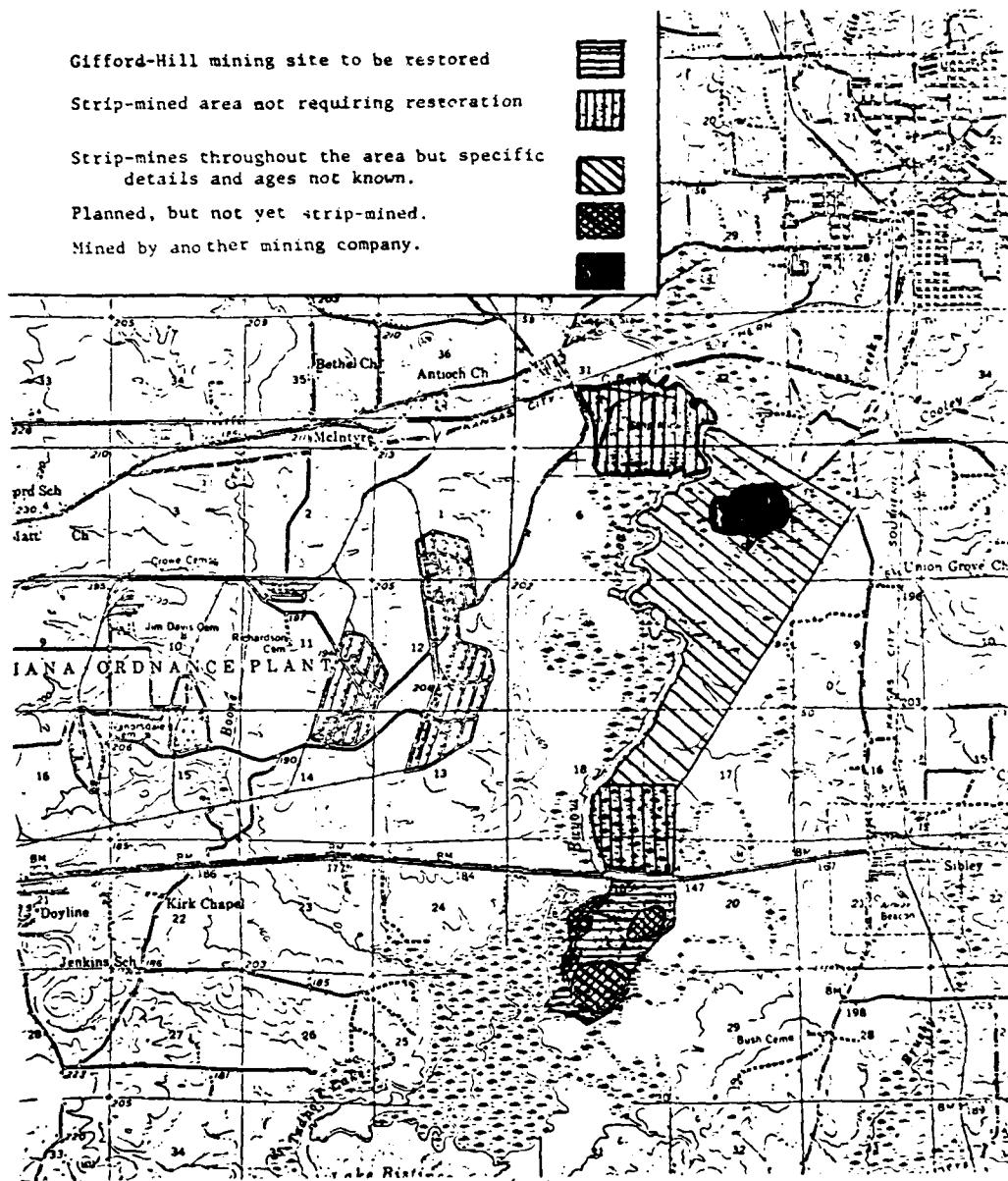


Figure 18. A topographical map showing the mining site on Bayou Dorcheat and Lake Bistineau

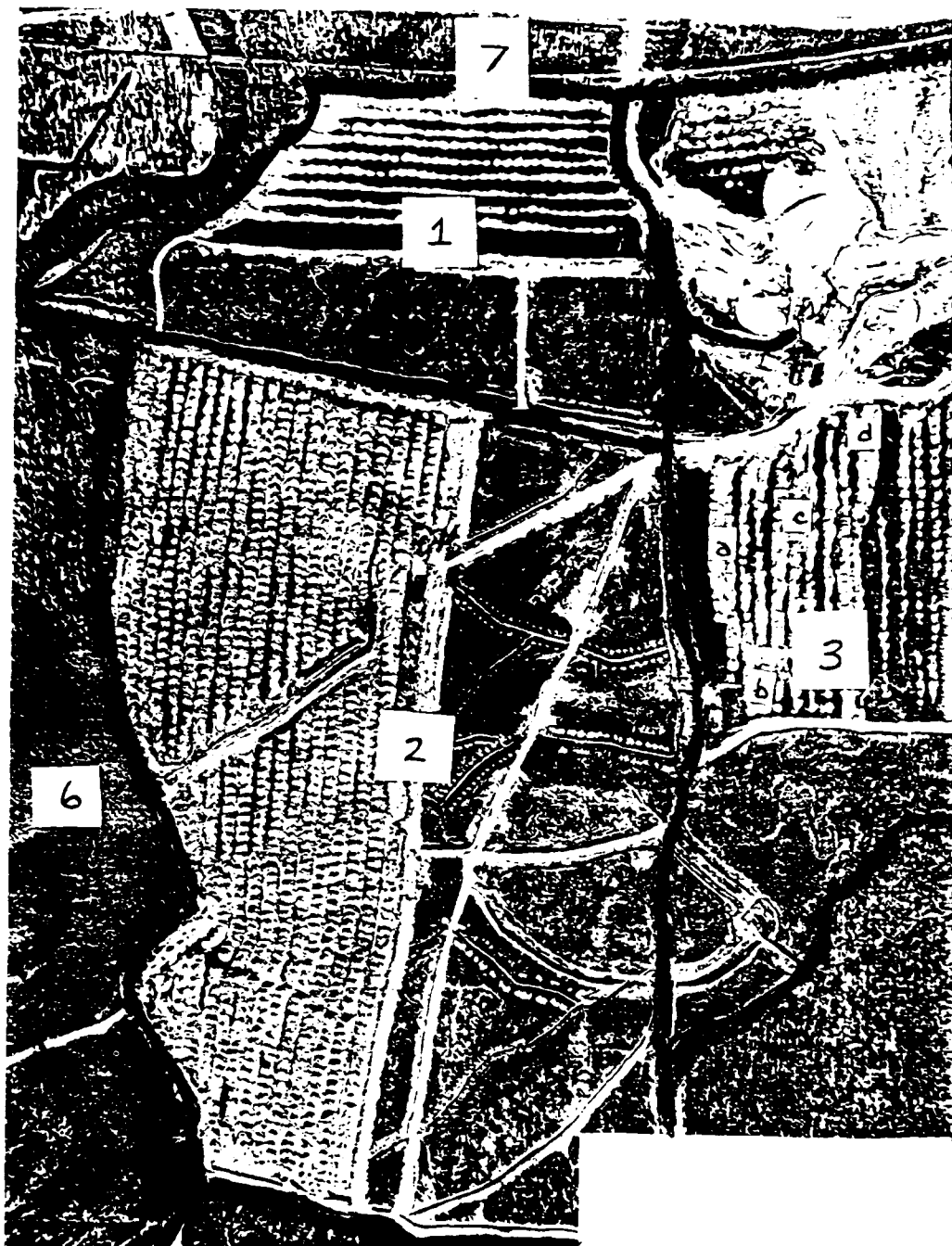


Figure 19. A 1978 aerial photograph of the northern parts of the area to be restored

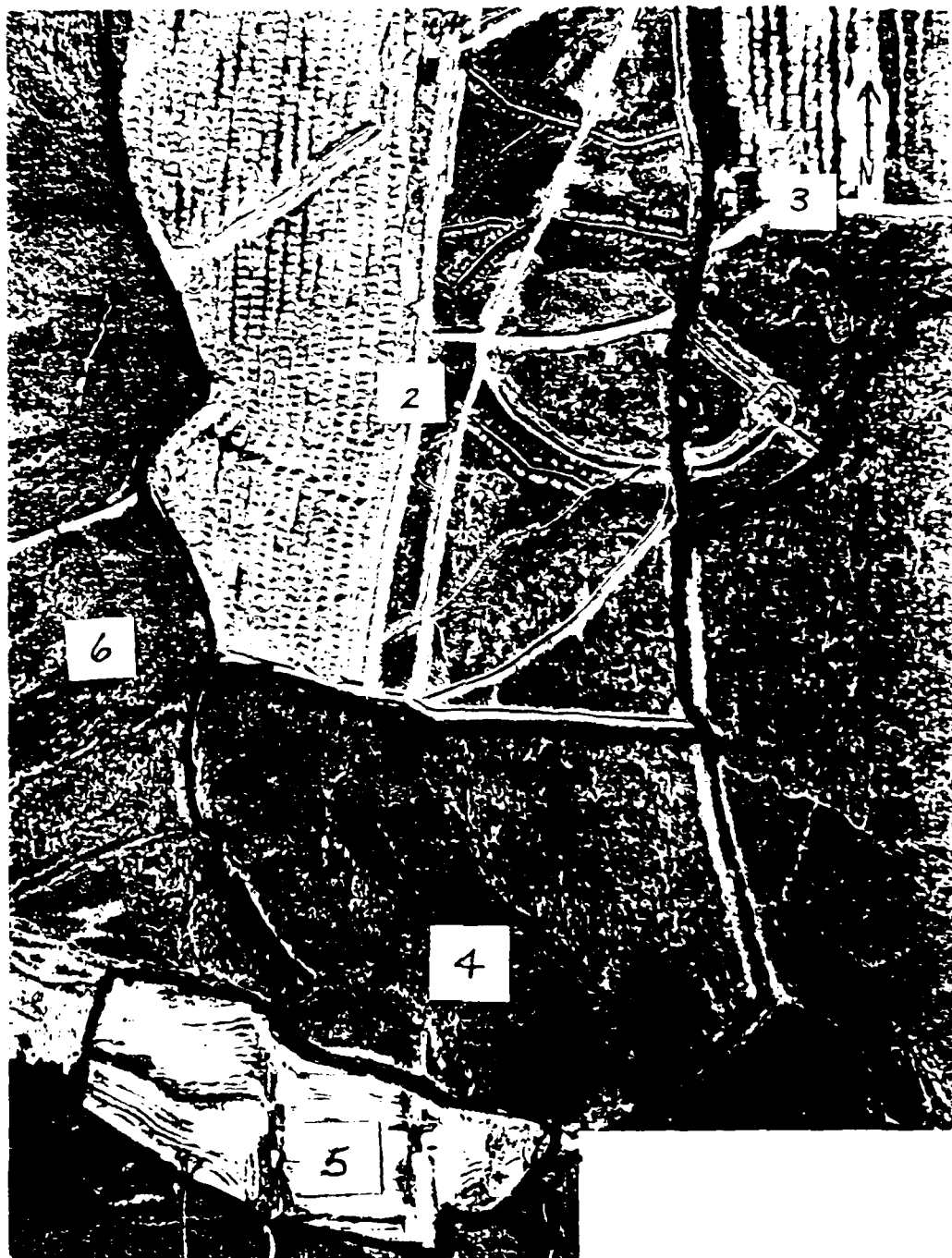


Figure 20. An aerial photograph taken in 1978 showing the southern parts of the area to be restored

Site Characteristics

208. Gifford-Hill's mining techniques have been to dike large areas of wetlands (Figures 21a and 21b), pump out standing water (and continue to pump to remove rainwater and seepage), cut and log out all usable bald cypress and hardwoods, remove twelve feet of soil overburden by dragline, then remove gravel deposits below to depths down to 30 feet and deeper. The results are long, continuous rows of soft mounds 15-40 feet high (Figures 22a and 22b) with troughs 15-30 feet deep which remain devoid of vegetation and wildlife for years. When the pumps are removed, ground seepage and rainwater fills the dikes and ponds are formed which after a period of time become popular sport-fishing areas. The tops of the mounds are left exposed and these isolated areas either slough off into the ponds or revegetate slowly (Figures 23a and 23b), depending upon their original stability. Vegetation on the mounds is often pine and other upland trees with some cypress and willows beginning to grow at water's edge. However, in most cases, the sides of the mounds drop off too quickly for cypress colonization. Alligators and other semi-aquatic wildlife forms live in and around these ponded areas. Shallow areas within the ponds are readily used by spawning fish. Some waterbirds use the limited shallow water areas for feeding and a colony of herons and egrets is located in the adjacent undisturbed bottomland hardwoods.

209. Soil mounds range in pH from 4.0 to 7.0 and water pH is usually around 7.0, according of Gifford-Hill personnel who were consulted prior to development of these plans. Water is monitored on a regular basis and pumped into holding ponds by Gifford-Hill personnel to meet Environmental Protection Agency standards for water quality. Soils are a mixture of silt with some sand and smaller amounts of clay. It is well mixed after strip-mining and typical of most southern soils in that available nutrients are leached rapidly from the top soil. Fertilizer, especially nitrogen, will probably be required for satisfactory growth of any vegetation planted on the site.



Figure 21a. A view of the cypress swamp located at the base of the Gifford-Hill dike. Habitat similar to this was originally inside the dike and has been strip-mined



Figure 21b. A buttonbush area with aquatic plants growing inside it at Bayou Dorcheat outside the Gifford-Hill dike. Habitat such as this was also displaced or mined



Figure 22a. A view of mounds left behind during the strip-mining operations. This material was formerly overburden and had to be removed to reach the sand and gravel deposits beneath



Figure 22b. As shown in this photo, the mining operation covers a very large site in the wetlands adjacent to Bayou Dorchet, and presents a good indication of the magnitude of the restoration needs and problems



Figure 23a. A view from the top of the dike of Section Seven. It is in the process of natural restoration and is slowly revegetating. The small mounds left are of little use to wildlife; however, the pond areas offer excellent sports fishing recreation



Figure 23b. This photo gives an indication of the amounts of material removed as shown by this dike road underlain with gravel deposits in Section One

210. Lake Bistineau's spillway is 141 feet above sea level. The prevailing elevation throughout the area to be restored ranges from less than 138 feet to approximately 150 feet above sea level. Bottom-land hardwoods and/or high marsh vegetation generally begin in the area at 142-144 feet and intergrade down to 138-140 feet where cypress swamps and low marsh/aquatic vegetation are found. Below 141 feet is usually standing shallow water which is usually characterized in that part of Louisiana by buttonbush flats, cypress trees, and aquatic mats of duckweed, fanwort, coontail, and other aquatic plants.

211. Climate in the area is warm and humid in summer with cool, moist winters. Occasional low temperatures of 10-25°F are reached. Rainfall averages approximately 55-60 inches per year. The year of 1979 has been unusually wet and rainfall has already at mid-year exceeded the average rainfall expectations. This has caused unusually high water levels on Bayou Dorcheat and in Lake Bistineau, and has hampered work by Gifford-Hill.

Site Restoration

212. For purposes of this report, the area to be reclaimed has been divided into seven sections (Figure 19 and 20). These seven sections were strip-mined or are planned for strip-mining and are of different ages, making any specific recommendations difficult unless age distinctions are made. Even though the sections were originally of varying elevations, this no longer is relevant since the area has been severely impacted by the formation of mounds and removal of the sand and gravel.

213. Throughout all sections it should be noted that disturbed lands with fluctuating water levels may leave isolated stagnant pools of water during low water periods and tend to become mosquito problems. This has been noted with dredged material disposal areas and similar sites. Care should be taken to see that proper grading and sloping are done so that pools of this nature, left standing behind uneven ridges in the various sections, will not occur if it is determined that

large mosquito populations are indeed associated with the strip-mining area.

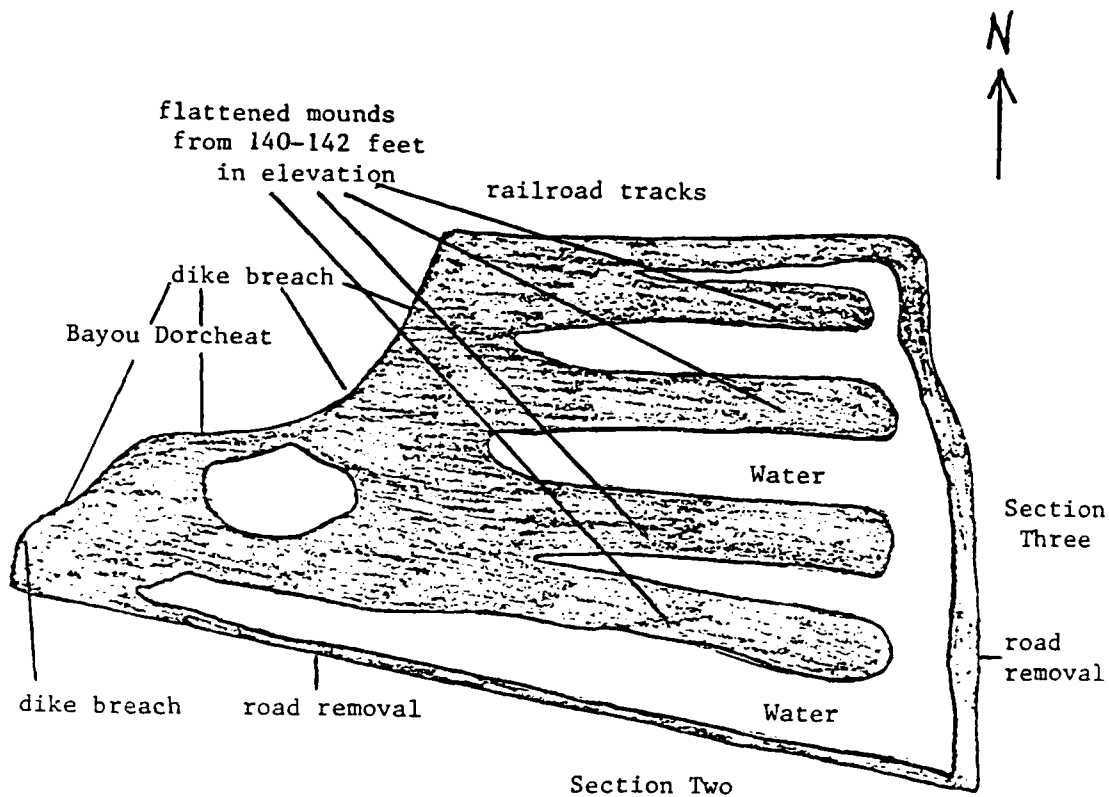
Section One

214. This section presently is diked and contains mine tailings of one, three, and four years of age. The older mounds have become hardened and have sparse grasses and herbaceous plants growing on them, with rushes, nutsedges, and other emergent marsh plants growing in the depressions.

215. The newer mounds are less than one year old and are quite soft. They have no vegetation and are unstable and steeply sloped. They retain ground moisture to such an extent that heavy equipment cannot work the section without difficulty. According to Gifford-Hill personnel, bulldozers have in the past suddenly dropped into soft pockets of soil and become deeply embedded in the mounds, requiring several more pieces of heavy equipment to pull them out.

216. This section is on the east bank of Bayou Dorcheat and would be subjected to annual flooding if the dike was breached or removed. The section would provide the widest range of habitats if these recommendations are followed (Figure 24):

- a. Using heavy equipment, pull together large land masses where mounds are closely located. The larger the land mass that can be formed, the better the habitat will be for wildlife within that section. Level the mounds in the process of consolidating the land mass and bring them to an elevation as close to 140-142 feet above sea level as possible. This elevation will allow natural formation of bottomland hardwoods of oaks, hickories, ashes, and pecans, as well as birches and other associated understory vegetation.
- b. Since there is not enough remaining soil to bring the entire section to 140-142 feet, the remaining pockets and troughs should remain basically untouched with the exception that gentle slopes from the land masses into the pond areas should be built to allow a more gradual change in vegetation and a more diverse habitat for use by wildlife. This will also prevent sloughing of the mound banks back into the water when the section fills.
- c. Breach the existing dike in at least two wide places on the side by the banks of Bayou Dorcheat to allow floodwaters into the section. Be sure that the breaches are not



Scale: 1 inch = 600 feet

Figure 24. A sketch of Section One as it should appear after mounds in the section are flattened and shaped. The shaded area represents land mass. A characteristic of strip-mining is that whatever side the stripping began on will have the most land mass, and the side where stripping stopped will be a deep water trench. A deep hole on the western side close to the dike should remain as is, as reworking mounds to fill it will involve unnecessary expense, and a pool located in the center of the land mass will serve to further diversify the created wetlands habitat

connected to the pond areas at an elevation of less than 141 feet, as this would allow the pond areas to be drained each year when the water level in the bayou drops.

- c. The introduction of seeds and/or seedlings of water oak, overcup oak, Shumard oak, Nuttall oak, willow oak, cow oak, water hickory, bitternut hickory, shagbark hickory, pecan, green ash, and other bottomland hardwoods species will hasten the process of habitat formation.

217. The engineering difficulties of working on an unstable soil in this section are not insurmountable, but they will cause time delays and more expense.

218. When the work is completed, if water is not flowing properly into the area, more breaches in the dike or its entire removal may be necessary. The section will serve to slow down runoff into Lake Bistineau through Bayou Dorcheat if adequate floodwaters are allowed into the section. This is a typical characteristic of all bottomland hardwoods in that they will help to slow down runoff and therefore help with flood control. They also help trap silt that would otherwise settle in Lake Bistineau.

219. Consideration should be given to placing the soil at a slightly higher elevation than 142 feet to allow for consolidation of the material when water is reintroduced into the section. Otherwise, a shallow overall pond may result that will become a cattail or rush marsh or a buttonbush flat. A soils engineer should be able to predict for Gifford-Hill what consolidation levels of the soil will be.

Section Two

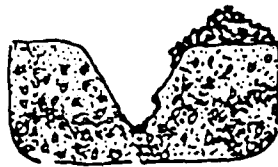
220. Section Two is the largest section in the restoration area and contains a series of about 32 rows of mounds half a mile long. It has been stripped over the past year and is still being actively mined. Mound tops in the older section were flattened to some extent earlier this year by Gifford-Hill and planted with live oaks and common Bermuda grass in an effort to begin compliance with Corps permit requirements. The area is eroding badly and while some of the trees are surviving now, once water is allowed to reenter the area, they will probably die from exposure because of incorrect elevations and water tables for that species.

221. Before restoration work can begin in earnest in this section, the surviving trees (now 1 to 2 feet high) should be dug up carefully with a soil ball left around the root system and heeled into a protected semi-shaded area in soil, sand, or sawdust to keep them from dying. They can be replanted in any appropriate section at the right elevation once the shaping work is completed and water is allowed to re-enter the sections. Minimum care of these trees while heeled in will be watering with a sprinkler/hose weekly and replenishing the soil, sand, or sawdust if it washes or blows away. There is little danger to the young trees of freezing or dying if heeling in is properly carried out using standard plant nursery techniques (Figure 25). Note that Figure 25 only shows bare root seedlings being heeled in. The same principle applies for seedlings with soil balls except that a larger hole must be dug to accomodate the soil ball and that seedlings are heeled in individually instead of being in bundles as with small bare-root seedlings.

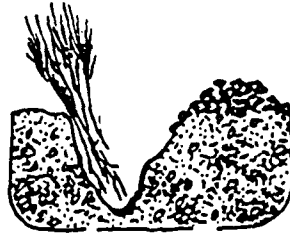
222. It should be pointed out that when actual costs are considered it may be less expensive to sacrifice the tree seedlings already planted and to acquire new plants rather than dig up, heel in, and replant the existing tree seedlings in Section Two.

223. Original elevations in this section ranged from less than 138 feet to approximately 142 feet. The dike which surrounds the section and water pumps keep out the water that would naturally cover a large part of it. Recommendations for restoring this area are diagrammed in Figure 26 and include:

- a. Pushing every other row of mounds into the one immediately adjacent to it to form a wider land mass consisting of two or more original rows of mounds. This would result in approximately 12-15 long strips of land throughout the section with stretches of water between them.
- b. As the bulldozer works the soil, a gentle slope should be made on each side of the land masses to increase plant and wildlife species diversity and to prevent excessive erosion. An elevation of 140-142 feet would be best, but high spots that must be left will provide still another type of habitat and therefore are acceptable.



1. Dig V-shaped trench in moist shady place.



2. Break bundles and spread out evenly.



3. Fill in loose soil and water well.



4. Complete filling in soil and firm with feet

Figure 25. Sketch showing heeling in of small seedlings that can be handled in bundles. Heeling in larger seedlings and seedlings with soil balls around their root systems is similar, but in that case individual plants are heeled in rather than in bundles. All heeled in plants require regular watering and some care

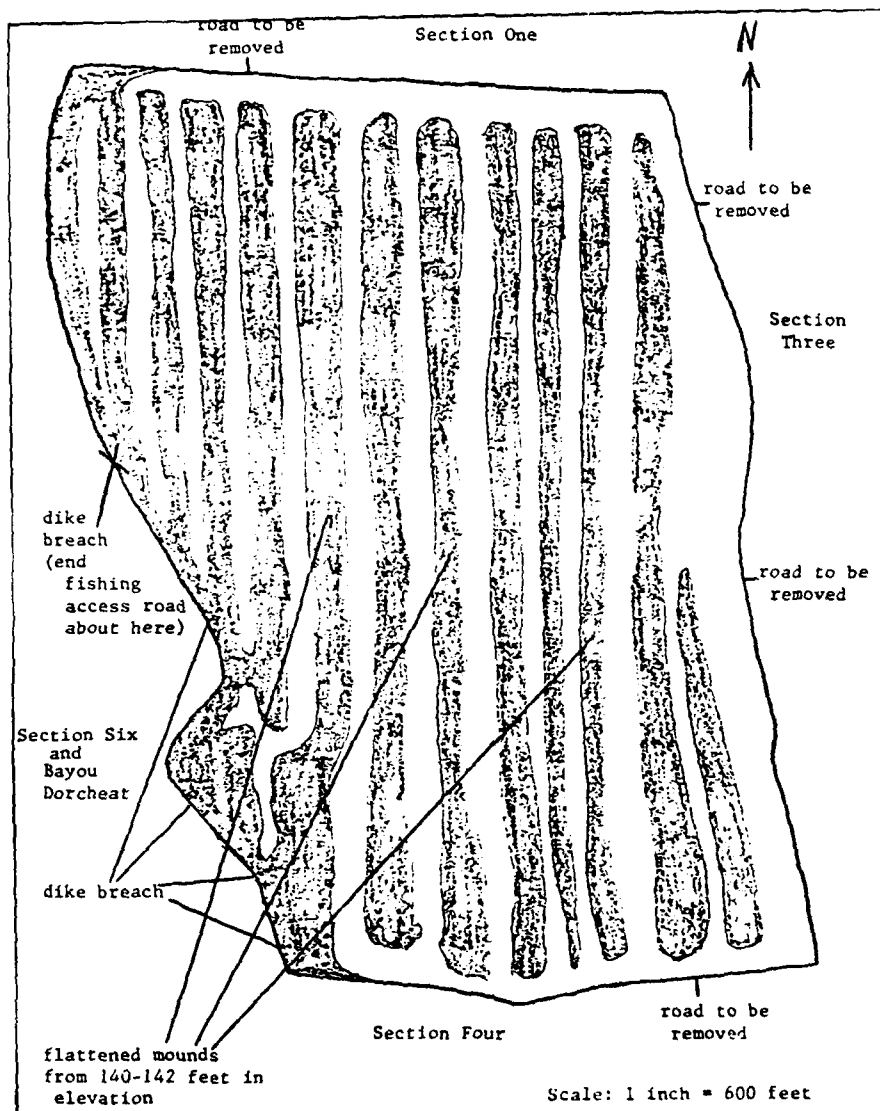


Figure 26. A sketch of Section Two as it should appear after mounds in the section are flattened and shaped. The shaded area represents land mass. Tree seedlings and/or seeds should be planted after water is allowed back into the section so that they will be planted at the right elevation for correct growth, survival, and reproduction

- c. Long deep trenches on the north and south ends should be left "as is" for two reasons:
 - (1) To provide deep water fisheries habitat.
 - (2) To provide isolation and protection of land masses, which will decrease human use and increase wildlife use, especially by waterfowl, waterbirds (herons, egrets, anhingas, and others), and songbirds that normally live in the northwestern Louisiana area.
- d. Gifford-Hill has indicated they will remove dike roads between Sections One, Two, Three, Four, and Six to mine the gravel underneath. The tailing left from road removal in all sections should be shaped to a gentle slope as the equipment moves out of the area for the last time and be allowed to develop naturally into marsh or shallow water habitat.
- e. The dike should be breached or removed next to Bayou Dorcheat to allow floodwaters to enter the section. If breaching is the option taken, then it would be possible to breach at strategic places that would still allow limited vehicular access for fishing purposes (Figure 26). Total removal of the dike would be costly and would remove the potential for an upland ridge of trees and other plant species, but would allow unobstructed access to the section during high water. The section would then serve as a flood protection measure as it would have the capacity to trap and utilize large quantities of floodwaters and slow down runoff into Lake Bistineau.
- f. Care should be taken to prevent connection of pond areas to the bayou at lower elevations than 141 feet as ponds will drain into the bayou and prevent their use as yearround fisheries.
- g. An option for this section that can be readily and inexpensively accomplished is that, once the land masses are shaped and water levels have been stabilized in the section, 100-200 wood duck nesting boxes could be built and erected on 8-10 feet high durable predator-proof poles at water's edge throughout the section. The advantage of such a procedure is that while the habitat is otherwise ideal for wood ducks, it will take close to 50 years to produce large trees with hollow and natural cavities suitable for wood duck nesting. A requirement here is that predator-proof poles must be installed or more harm will be done than good. Wood duck hens are attracted to nesting boxes. If they are not predator-proofed by use of metal shields or some other means, nearly all nests in the boxes will be destroyed by rat snakes and raccoons.

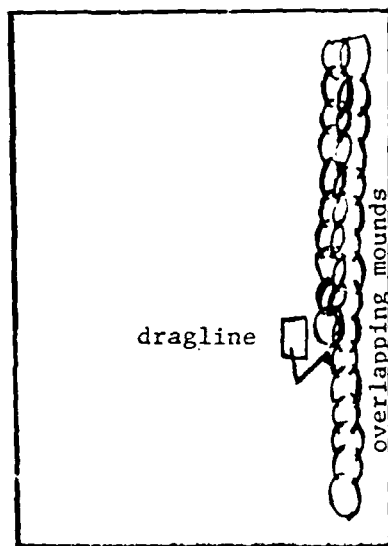
- h. Seeds and seedlings of bottomland hardwood tree species already listed in Section One can be planted on emergent mounds after water has reentered the section. The need for planting trees after water comes in is to better determine water levels and therefore have the trees planted at their best elevation for survival and reproduction. The young live oaks removed from the section and headed in could be replanted here or in other sections at elevations above 144 feet (above the high water mark) in well-drained soil.

Section Three

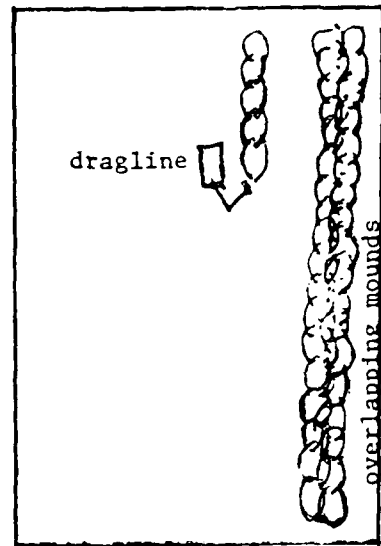
224. This section is older and is being heavily used by Gifford-Hill. Most of it has been mined and is now filled with water; the middle part was mined in 1975 and the northern part prior to that time. The northern part is presently being used as the office and physical plant of the mining operation. No reshaping of mounds or dike removal has been done in the section. The southern part of Section Three has been ditched and diked but not mined.

225. Figure 19 shows the emergent mounds in Section Three. Note the closeness of mounds at points a, b, c, and d. Level land masses at these points could be formed, but would require pumping out the standing water so that access to the mounds could be gained. The other mounds in the section are already mostly submerged and would remain so even with breaching of the dike and removal of the road. They should remain as they are for fisheries habitat and shallow marsh. If the land masses are formed at points a, b, c, and d, they should be leveled to 140-142 feet and planted with the seeds and seedlings recommended in Section One.

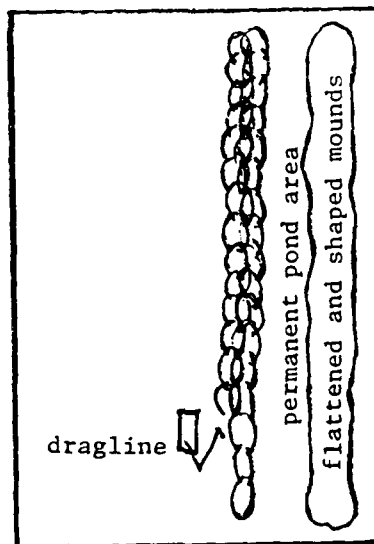
226. The southern part of Section Three has not yet been mined, which presents an excellent chance to develop bottomland hardwood habitat while the strip-mining is taking place. When mining begins here, the dragline operator should place two rows of mounds together as closely as possible (overlapping if possible) and knock off the tops of the mounds into the trough between the two overlapping rows. This allows easier access by bulldozers to the mounds to do final shaping and helps them have a stable substrate on which to maneuver their equipment (Figure 27a, 27b, and 27c). Wider water expanses would result between the overlapping mound rows.



a. Dragline placing mounds in overlapping position



b. Dragline placing third row of mounds away from first two overlapping rows of mounds to create a permanent water area between the mound rows



c. Dragline placing mounds on fourth row overlapping third row, with overlapping rows one and two flattened and shaped by bulldozer

Figure 27. Three sketches showing method of overlapping rows during the mining operation to make the habitat restoration process an easier, on-going operation. It is also more cost-efficient to restore the area as it is being mined

227. Shaping by bulldozer will be held to a minimum using the preceding dragline method. A gentle slope is still necessary, but should be much easier to accomplish since the bulldozer will have a firmer footing from which to work. An elevation of 140-142 feet should be achieved if possible.

228. The overlapped and flattened mound rows can be planted with trees recommended in Section One. The mound rows should be kept isolated for more wildlife use and the dike should be breached or removed to allow floodwaters from the bayou to reenter the section (Figure 28).

Section Four

229. Section Four is very similar to the southern part of Section Three. It has not yet been mined although much of the timber has been removed already. The technique described above with overlapping, flattened mound rows at an elevation of 140-142 feet will create suitable bottomland hardwood areas interspersed with ponds (Figure 29).

230. When the gravel is removed and as the equipment moves out for the last time, the overburden making up the existing roads should be levelled and sloped to create shallow water habitat or emergent marsh. Land masses may be planted with seeds and/or seedlings of recommended plant species listed in Section One.

231. Section Four is surrounded by elevated roads on three sides and by a dike on the east. The roads will be removed and the dike should be breached in several places or removed to allow flood waters to enter the area. As in Section Three, this section will act as a natural flood control area and slow down runoff into Lake Bistineau.

Section Five

232. Section Five was a cypress swamp that was mined in 1978. Its original elevation was probably less than 138 feet. If the remaining soil which was originally overburden was leveled, the section would be a lake several feet deep. The only way to obtain any bottomland hardwood areas within this section is to use a bulldozer or dragline to reshape mounds of existing material and create higher elevation spots that are as large as possible. Deep water spots will remain as is, but gentle sloping of the mounds should be done to slow

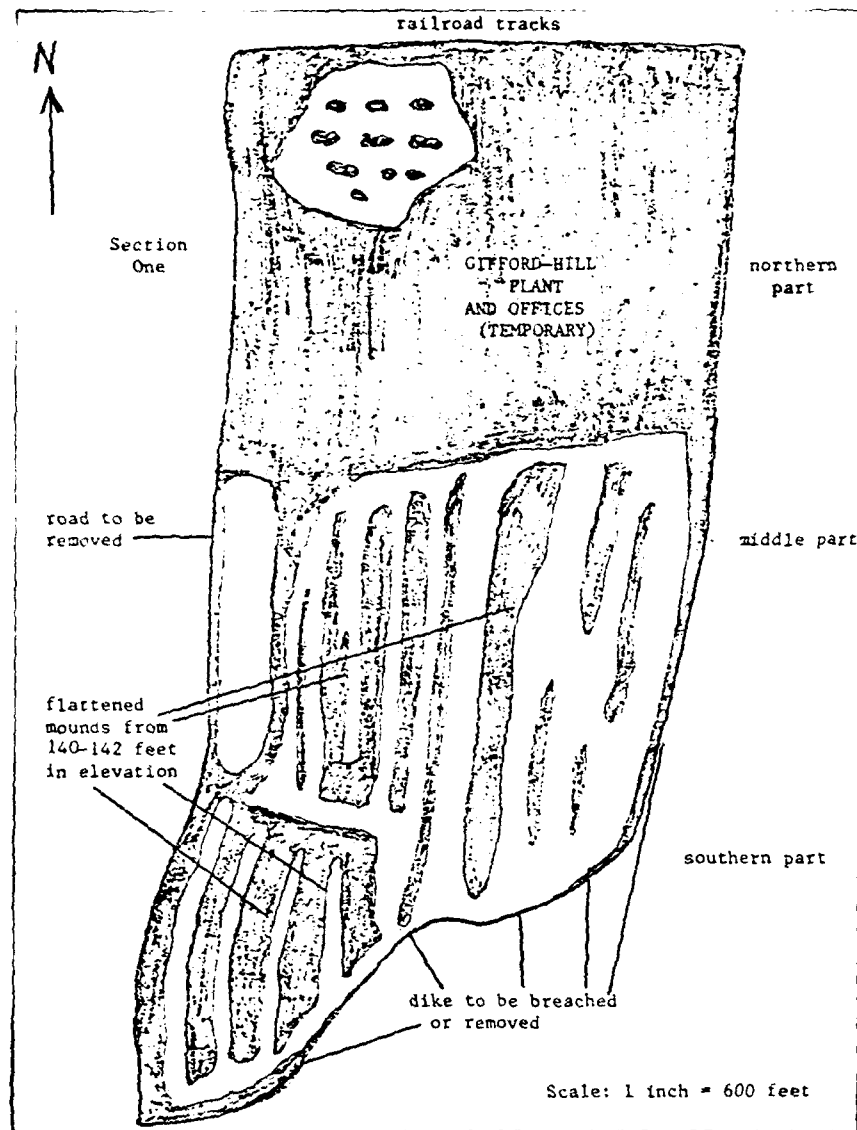


Figure 28. A sketch of Section Three as it should appear after mounds in the section are flattened and shaped and the southern part has been mined. The shaded area represents land mass. The pond in the northern part may be filled from washings from the adjacent Gifford-Hill physical plant

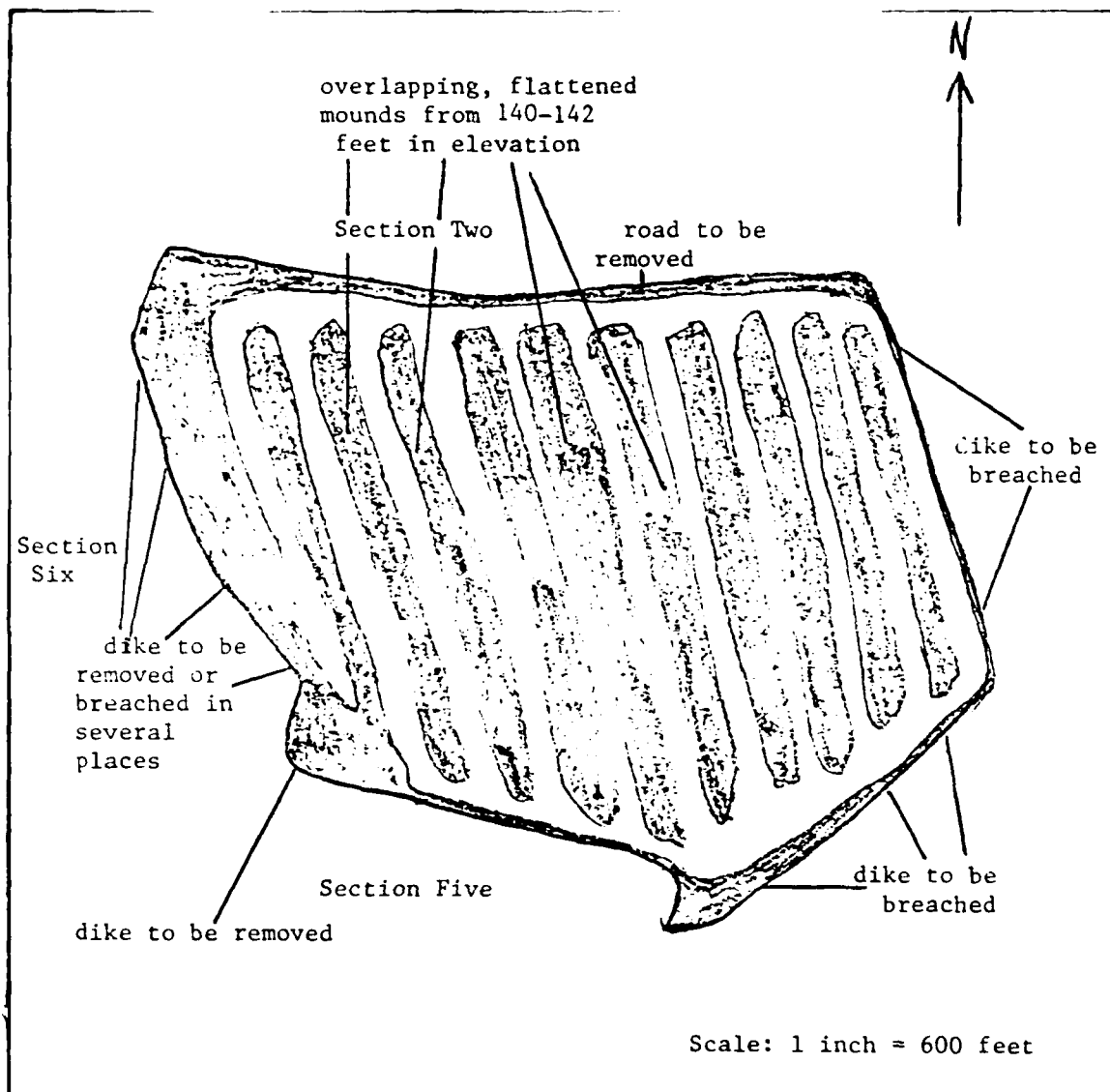


Figure 29. A sketch of Section Four as it should appear after strip-mining has taken place and the mounds in the section have been flattened and shaped. The shaded area represents land mass. The long strips of land mass are made up of overlapping rows of mounds between water troughs

down the runoff and to ensure some shallow water areas for fish spawning (Figure 30).

233. This section is close to Bayou Dorcheat and at the southern end of the impacted area. When mining work is completed, the dike should be removed completely to allow bayou water and floodwaters to enter.

234. Section Five is the one most likely to revert back to cypress unless the water level is too deep to allow colonization via cypress seeds. The higher land masses with elevations of 140-142 feet will be isolated islands. They could be planted with mast trees or could be left to colonize naturally from seed sources to the south and east of the section. However, planting of seedlings would be the most likely and quickest way to obtain bottomland hardwoods of the desired quality in this section.

235. Working this section with a bulldozer will be very difficult; a dragline may be required to knock tops off mounds to give the bulldozer a platform from which to operate.

Section Six

236. Section Six is a large area between existing mined areas and the west bank of the bayou. Roads have been extended into the area, but no dikes have been erected. The roads are presently breached by order of the NOD to allow water exchange to occur until a permit decision has been reached. This section consists almost entirely of very old stands of cypress and open water with some bottomland hardwoods on higher elevations. If these trees were cut, with the normal growth rate of cypress, it would take 150-200 years to replace the lost habitat in kind (Figure 31). Strip-mining would significantly impact the swamp/wetlands ecosystem and change it into deep water fisheries habitat.

237. If the section is mined, the same techniques outlined in Sections Four and Five would apply, especially Section Five, as the two sections were originally very similar.

Section Seven

238. Across the road from the main Gifford-Hill complex is a section that was mined years ago and that is not part of the required

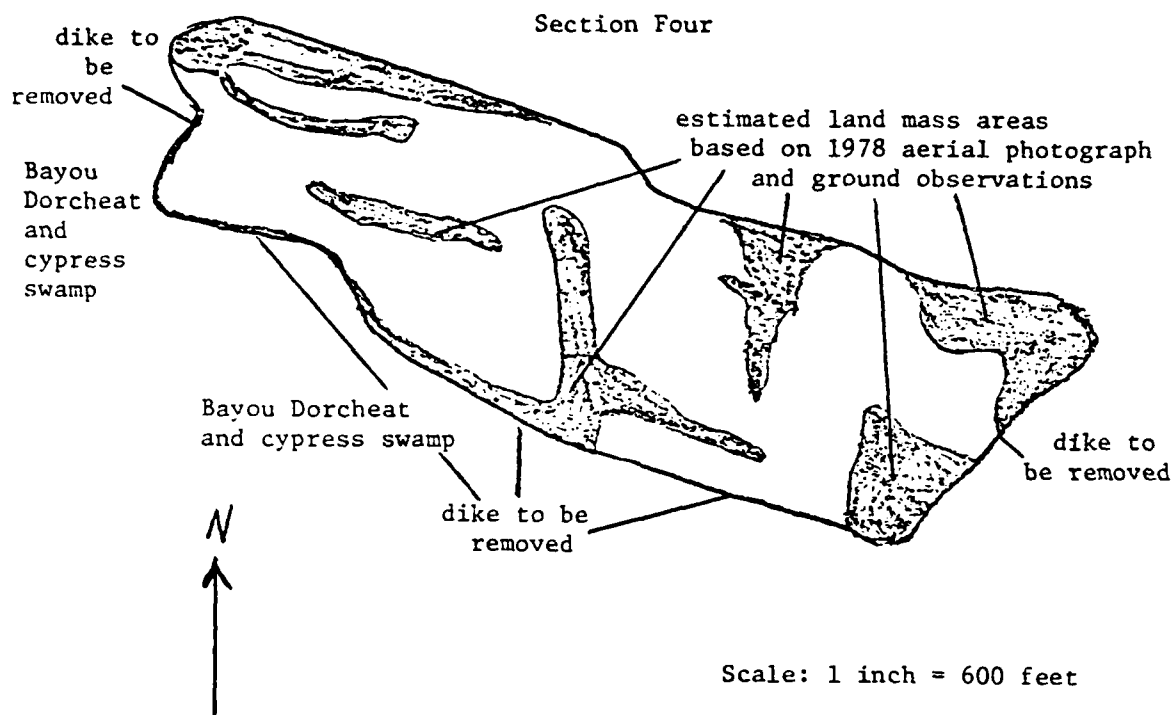


Figure 30. A sketch of Section Five as it should appear after mounds in the section have been flattened and shaped. The shaded area represents land mass. This section will primarily be water, as it was lower in elevation originally. Therefore, there will not be as much soil for use in bottomland hardwood habitat

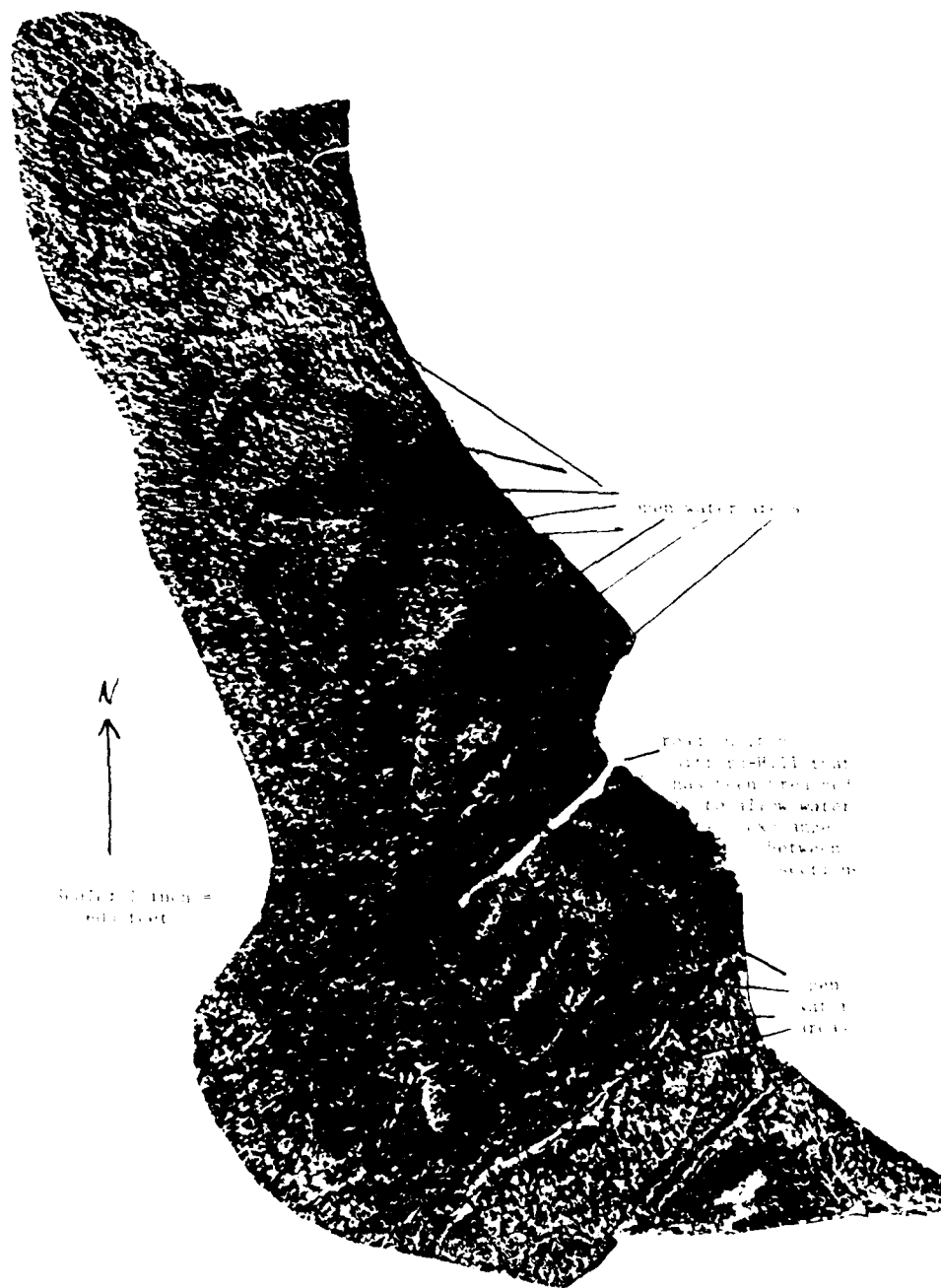


Figure 31. Aerial photograph of Section Six of the restoration area, showing numerous open water areas and cypress swamps. This area has not been mined

restoration. However, after studying the section and its topography, two additional recommendations are made:

- a. That 100-300 wood duck nesting boxes be erected at water's edge throughout the area. Again, as stressed in paragraph 222, these nesting boxes must be predator proof and at least 8-10 feet off the ground. Instructions for typical wood duck nesting box construction are shown in Appendix D. This habitat presently is ideal for wood ducks with the exception being a lack of nesting sites.
- b. That seedlings of willow oaks, water oaks, shagbark hickories, and pecans be planted on the mounds not yet covered with trees. Shagbark, pecans, and willow oaks should be planted only at the highest elevations (above 142 feet), with water oaks planted closer to water's edge. Cypress seedlings may be planted in the edge of the water, but seeds probably would not survive the non-fluctuating water levels existing in the ponds in Section Seven.

Planting Requirements and Costs

239. If a decision is made to plant seeds and/or seedlings in the various sections as previously discussed, it would be helpful to point out some problems and requirements that may be encountered.

240. The tree species recommended in Section One as being suitable for bottomland hardwood development were selected because of their tolerance of flood conditions in northwestern Louisiana. This tolerance is primarily during dormancy, but they will survive several-day floods during the growing season to varying degrees depending upon the species. No understory trees and shrubs or herbaceous wetland plants were recommended as they will naturally colonize a wetland area that provides them with their growth and reproduction requirements.

241. The primary considerations in planting the Gifford-Hill site are availability of seeds and/or seedlings and costs. Obviously, if the area is allowed to colonize naturally, there will be no planting costs.

Sources of plant material

242. There are a number of sources of plant material available to Gifford-Hill:

- a. The U. S. Forest Service has a tree nursery located at Pollack, Louisiana, which grows numerous tree species. Inquiries and orders for trees could be placed with them in advance to ensure the availability of the needed tree seedlings. They may also be able to provide seeds. The Forest Service will not plant the seedlings or seeds they provide.
- b. The Soil Conservation Service maintains nurseries at various locations throughout the United States. Their nursery located at Coffeeville, Mississippi, would be able to provide tree seedlings. An advance order, preferable of one year or more, would be necessary to obtain seedlings from their nursery. The Soil Conservation Service will not plant seedlings and their nursery stock will be provided bare root.
- c. The state nursery for Louisiana located at Baton Rouge sells native plants and trees. Again, an advance order would be necessary in order to ensure the needed tree seedlings and seeds. It is not known at this time if this nursery is willing or capable of planting the seedlings and seeds they would provide.
- d. Collection of seeds by knowledgeable personnel hired by Gifford-Hill would probably ensure seed supplies; however, a commercial or government nursery is the only recommended source of seedlings. Attempts to gather tree seedlings from natural stands is not recommended and should not be made. Trees dug from natural stands have not been root-pruned and are subject to severe shock when they are moved; survival rate is low.
- e. A good, reputable commercial nursery in the Shreveport/Sibley area could obtain for Gifford-Hill on advance order young trees in containers suitable for transporting to the sites and transplanting on the sites. The nursery company should be capable of doing all preparation for planting and of doing the planting work, thereby relieving Gifford-Hill employees of that effort.

Costs

243. Plant material costs can vary considerably depending upon the sources chosen of the ones listed above. In general, orders for plants should be placed at least one year in advance of planting needs to ensure an adequate supply of nursery-size tree seedlings. Depending upon species, seedlings supplied should be from one to four feet high. The least expensive option (A) is probably having the U. S. Forest Service or Soil Conservation Service nurseries provide seedlings to be

planted by Gifford-Hill employees. The next least expensive option (B) would be to obtain the seedlings from the Federal or State nurseries and hire a reputable commercial nursery to plant them properly.

244. The costliest option (C) would be to have a commercial nursery provide plants and also plant them on the sites. They would expect to bid for the job and a better price could be obtained by competitive bids from nurseries in the area. The major difference between options B and C is the fact that government nurseries are able to charge much less for nursery stock than a commercial nursery can.

245. Survival rates should be a primary consideration in determining sources of plant materials. Government nursery stock are often provided "bare-root" with no soil attached to root systems; survival is often not good. Commercial nurseries usually provide nursery stock that are either in nursery containers or balled-and-burlapped to protect delicate feeder roots and to lessen shock; survival is high. In addition, a reputable nursery will generally guarantee its work for at least one year and replace all plants that die free of additional charge.

Plant materials and techniques

246. On an area as large as the Gifford-Hill site, large quantities of plant material would be required. Trees should be planted according to elevation of the emergent mounds of soil after each section is refilled with water (Figure 32). No trees should be planted closer than fifteen feet to one another to allow best growth and development of canopy. At any given elevation tree species planted should be mixed, i.e., any species of oak (except live oak) on the recommended list can be planted with any other and it would be desirable to do so (Figure 33). This would provide a better overall food supply for wildlife. For example, one species may produce a heavy crop of acorns one year while another species may have a crop failure in the same year. A mono-stand of any one tree species is not good from a wildlife value standpoint.

247. Based on the estimated land area that will be left exposed after water is allowed to fill each section, and considering that

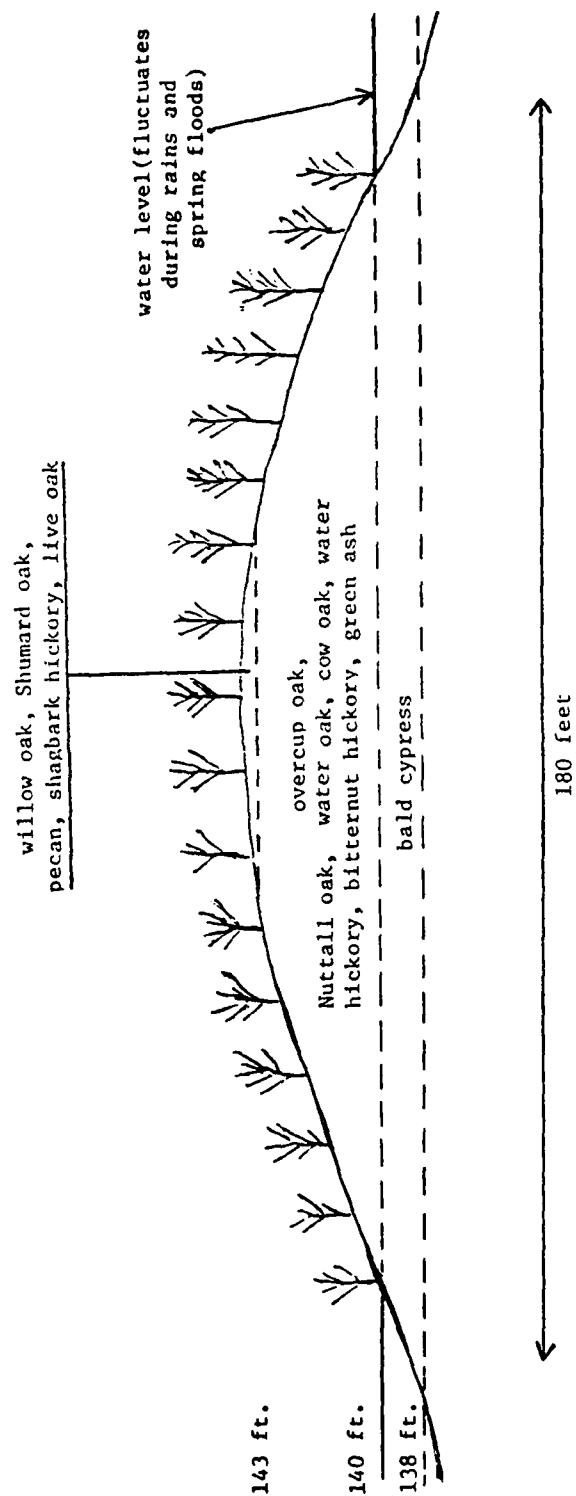


Figure 32. A sketch showing elevational requirements of recommended tree species for the creation of bottomland hardwoods

Legend:

1. Water hickory
2. Green ash or bitternut hickory
3. Water oak
4. Cow oak
5. Nuttall oak or overcup oak
6. Willow oak or Shumard oak
7. Pecan or shagbark hickory

Scale: 1 inch = 90 feet

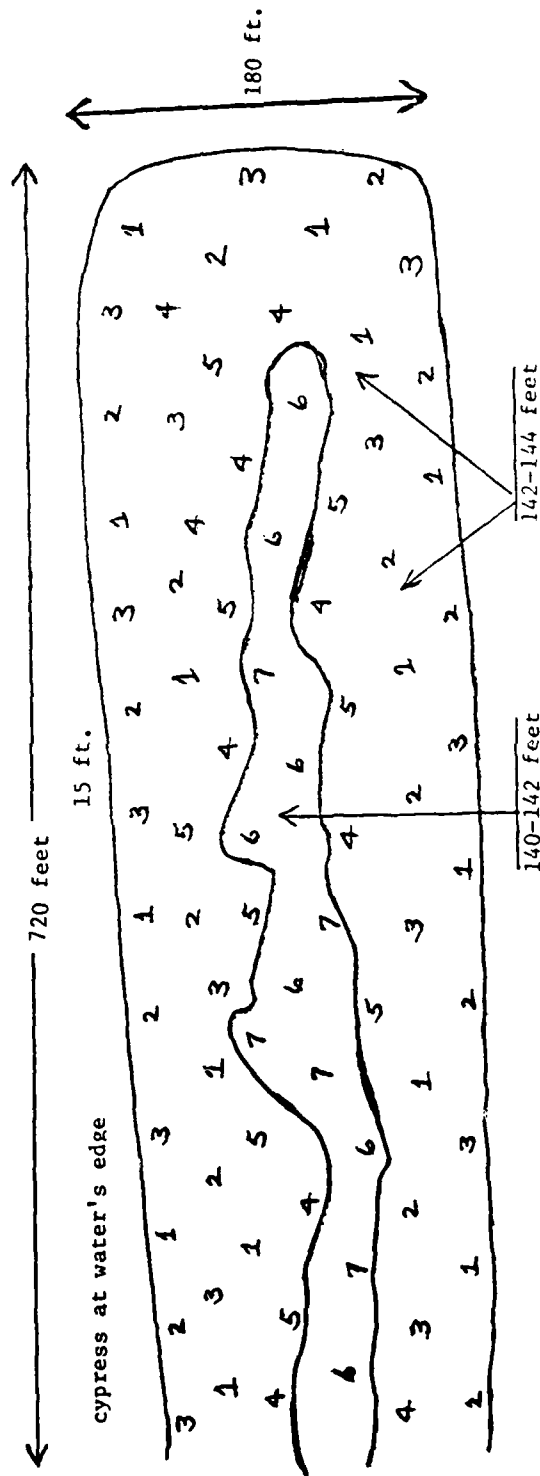


Figure 33. A sketch showing placement on a typical flattened and shaped row of mounds. Numbers correspond to the legend above

there is no need for a total coverage of all land mass with trees to ensure development of bottomland hardwoods habitat, the numbers of trees estimated to be needed for each section are presented in Table 1. A typical planting scheme is shown in Figure 33.

248. Cover crop for erosion control. To prevent erosion of emergent mounds, a seed mixture of white Dutch clover, common Bermuda grass, tall fescue grass, and perennial rye grass should be broadcast on each mound land mass with a hand-operated "whirly-gig" seeder. All-purpose fertilizer such as 13-13-13 N-P-K equivalent to 500 pounds per acre (#/ac.) should also be broadcast, with a top dressing of 200 #/ac. of ammonium nitrate. This seed mixture should provide a good cover for at least two years and will allow a stable substrate in which the small tree seedlings can develop. Seed survival and growth will be best if seeds and fertilizer can be broadcast on loose soil and can be covered with the soil by simple dragging or sweeping with a board or rake. Seeds can be planted at any time of the year that the ground is not frozen, although seeding is usually best either in the spring or fall. The important thing is to get them planted as soon as possible after mound shaping is completed and water has reentered the section to prevent erosion.

249. Trees. During and after water levels have stabilized, trees should be planted using standard nursery techniques. The following techniques are for planting larger bare-root trees or containerized nursery stock. Figure 34 shows methods for planting very small bare-root seedlings using a dibble planter. This type of seedling may be all that can be provided by a government nursery. Techniques for containerized or larger stock are:

- a. Dig a hole twice as deep and three times as wide as the roots of the seedling trees (or soil ball of containerized nursery stock).
- b. Fill the hole half full of a good loose soil, place the tree in the hole taking care to spread the roots out to prevent binding and to plant it at the same elevation from which it came, i.e., be sure all roots that were originally underground are placed underground at the same depth (Figure 35).

Table 1

Estimated Numbers of Tree Seedlings Needed per Section in the Gifford-Hill Project

Species	Sections							Total
	1	2	3	4	5	6	7	
<u>Above 142 feet</u>								
Live oak ¹	50	300	50	100	0	0	0	500
Pecan	70	360	185	170	0	0	300	1,085
Shagbark hickory	70	360	185	170	0	0	300	1,085
Shumard oak	70	360	185	170	0	0	0	785
Willow oak	70	360	185	170	0	0	150	935
<u>140-142 feet</u>								
Overcup oak ²	115	2,560	220	200	50	0	0	3,145
Nuttall oak	115	2,560	220	200	50	0	0	3,145
Water oak	115	2,560	220	200	50	0	150	3,295
Cow oak	115	2,560	220	200	50	0	0	3,145
Water hickory	115	2,560	220	200	50	0	0	3,145
Bitternut hickory	115	2,560	220	200	50	0	0	3,145
Green ash	115	2,560	220	200	50	0	0	3,145
<u>138-140 feet</u>								
Bald cypress ³	200	1,200	100	100	200	0	0	1,800

¹Limited to the seedlings already owned by Gifford-Hill and planted in Section Two at present.

²If species cannot be obtained, any other may be substituted. However, species diversity is the desired characteristic of a bottomland hardwood habitat.

³Optional--this species will colonize anyway if the proper elevation and water levels are present.

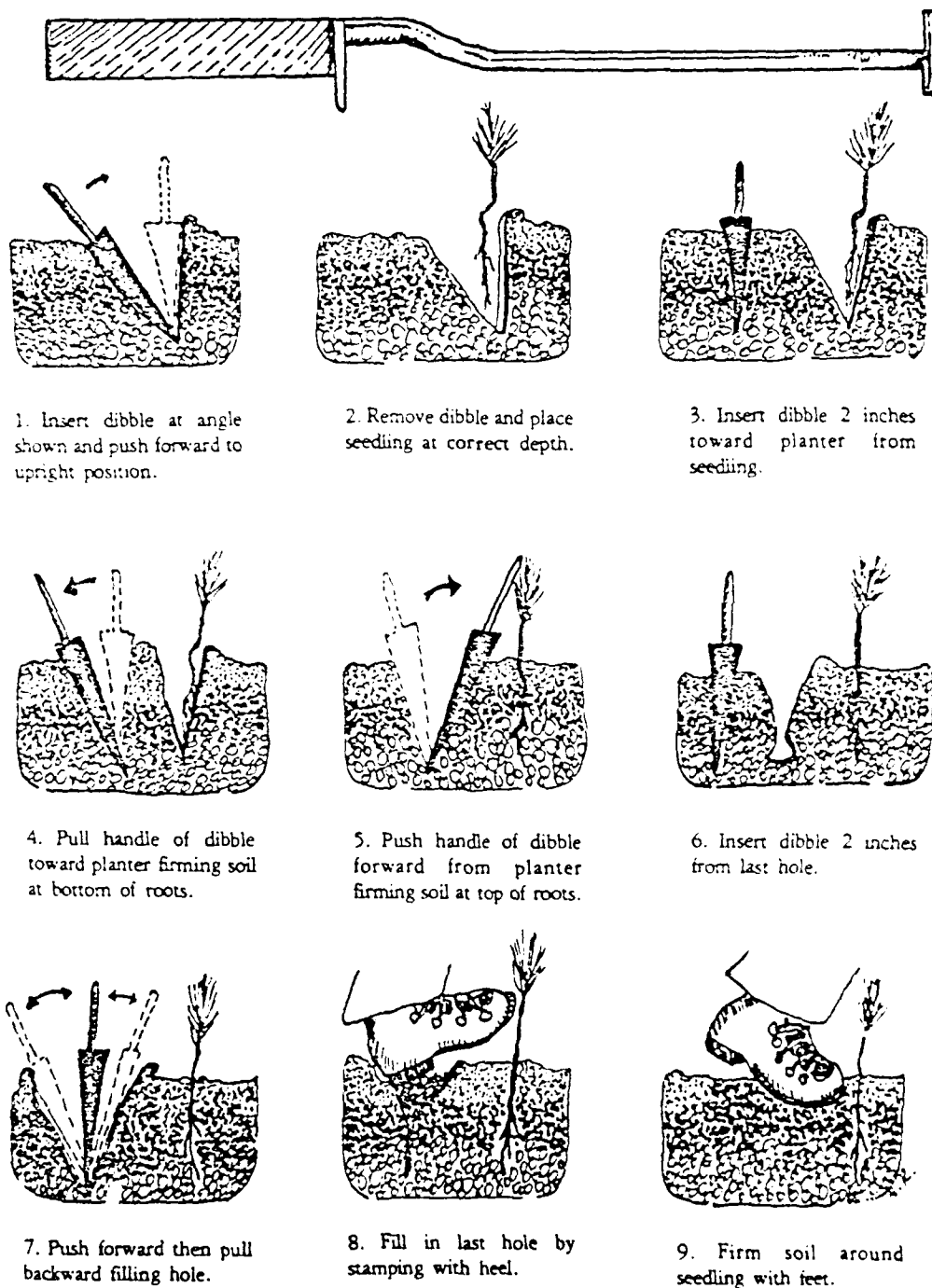


Figure 34. Sketch showing dibble planting of tree seedlings. This method is used for small tree seedlings that are bare-root

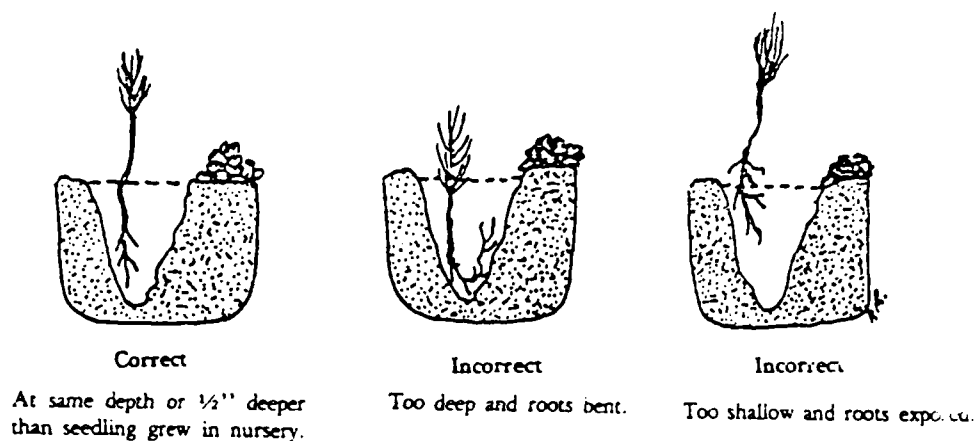


Figure 35. Sketch showing correct and incorrect ways to plant tree seedlings

- c. Fill the hole with water and add more loose, good soil to the top of the hole, taking care to cover all roots.
- d. Broadcast 1 to 3 tablespoons (heaping, or 1/3 standard measuring cup) of all-purpose commercial fertilizer such as 13-13-13 around the base of the planted young tree, taking care not to put the fertilizer on the tree or tree trunk.
- e. Firm soil around the tree while holding it in an upright position. It may be necessary to stake larger seedlings to maintain erectness.
- f. Water again. This is to ensure no air pockets remain around the root system which will dry out and kill the roots.
- g. Plant trees in the spring or fall preferably, but any time the soil is not frozen is acceptable. Southern summers are too hot and dry for transplanting and most of the seedlings would probably not survive if planted at that time.

250. Seeds. If tree seed mixtures (acorns, hickory nuts, and pecans) are used at all, they should be broadcast sparingly or planted with a trowel or commercial planter at not less than 8- to 10-foot intervals between each planting. A mixture of available seeds is best to prevent a mono-stand of one species from developing. These seeds should be able to compete successfully with little difficulty with the mixture of grasses and clover. Plant all tree seeds no deeper than 2

to 3 inches below the soil surface and tamp the soil firmly over the planted seeds.

Potential Wildlife Use of the Restored Area

Pond areas

251. It is expected that the pond areas in all sections will follow patterns developed in old strip-mined areas nearby in that they will develop into excellent sports fisheries pools with good stocks of game fish. This could be hastened by stocking of the ponds, but the fisheries will develop naturally through introduction of stock fish into the ponds during floods on the bayou if the dikes have been properly breached.

252. These areas will continue to be colonized and/or inhabited by alligators, muskrats, and other semiaquatic animals. Shallow areas will develop not only into good spawning areas, but should also be used heavily by wading and water birds (herons, egrets, anhingas, wood storks, and others).

253. During migration, the ponds will serve as stopover points for waterfowl moving south to the Louisiana and Texas rice fields or north to breeding grounds. Cavity-nesting wood ducks and hooded mergansers and marsh-nesting mallards are likely to feed there and to attempt to nest there, especially the wood ducks, the only true yearround waterfowl species in the South. They cannot use the sections for nesting, however, until nesting cavities either in the form of old hollow trees or nesting boxes are provided.

254. In addition to the larger and more conspicuous wetlands creatures, numerous invertebrate, amphibian, and reptilian species will make the ponds their year-round homes.

Land areas created from mounds

255. Initially, the land areas will be of little use to wildlife. However, as soon as water reenters each section and the cover crop of grass and clover is planted, small rodents and mammals should move into them. Ground-perching birds, raccoons, and numerous other species

with the capability of reaching an island by swimming or flying will also begin to use the mounds.

256. After the small tree seedlings and/or tree seeds are planted, there will be a period of several years required before they grow enough to be of real use as a wooded habitat. However, there will be a natural invasion at the edge of each mound of black willows and probably eastern cottonwood, with a few cypresses. Seeds from wind-blown sources of weedy species such as dog fennel and ironweed will also colonize. Fringes of freshwater marsh plants will begin to grow at water's edge also. These temporary plant communities will serve to protect the young trees as they grow. Rabbits, foxes, raccoons, opossums, bobwhite quail and all kinds of birds except deep woods species, and numerous rodents and reptilian species will use the areas at this stage of development.

257. After a period of 5-10 years, the young trees will begin to be dominant on the mounds. They will be frequented by nesting birds and provide cover for white-tailed deer. They will begin producing mast at about this age and slightly older, which will encourage use of the area by wild turkeys, squirrels, and other mast-eating species. If wood duck nesting boxes have been provided, wood ducks should be in abundance in the area.

258. There is also a possibility that this secluded wetland habitat will appeal to at least one protected and endangered species, the native red wolf, which now is believed to exist only in very low numbers either in captivity or in isolated pockets in the Louisiana/Texas border country if any remain at all.

259. As the vegetation matures and becomes heavily wooded, the open meadow wildlife species will move out and deep woods raptors, songbirds, deer, turkeys, and squirrels will increase in numbers.

Summary

260. Assessment of the Gifford-Hill strip-mining project indicates that habitat restoration is indeed feasible. However, the original

cypress swamp habitat will be replaced with as much bottomland hardwood habitat as possible with connecting deep to shallow pools of water to meet requests of other Federal and State agencies. It was not the purpose of this report to assess the impact of such replacement, but to offer practical recommendations for the restoration of the strip-mined area to a wetlands habitat.

261. Recommendations accompanied by simple sketches depicting habitat development concepts are presented in the body of the report. Planting guides and suggestions are also offered, as well as predicted wildlife use of the restored habitat over a period of years through plant community succession.

262. It should be noted that little baseline data were available or had been taken. Recommendations in this report were made using data provided by the NOD, the National Oceanic and Atmospheric Administration, and by personal communications with Gifford-Hill employees. It is suggested that before restoration work is undertaken (especially planting and establishment of bottomland hardwood trees), baseline data on soil moisture, pH, texture, flood levels over a period of years on Bayou Dorcheat, and water quality be taken. Without these data, the results could be poor restoration success due to planting trees at improper elevations.

PART VI: DREDGED MATERIAL USES AND DISPOSAL ALTERNATIVES
FOR THE TRINITY RIVER BASIN PROJECT, TEXAS

by

M. C. Landin and C. J. Newling

Preliminary Evaluation

263. The DOTS was asked to discuss disposal alternatives, placement of dredged material for habitat development, and habitat development possibilities in the Trinity River Basin Project. This discussion includes suggestions made by the Fort Worth District and by WES. Since the area under consideration is large and contains two general habitat types (fresh to brackish marshes and open water areas south of Wallisville Dam and freshwater cypress swamps and marshes north of the dam), the report is presented in two subsections, with final sections on general costs and recommendations.

264. Preliminary assessment of the request for assistance has shown that various technical aspects of the project require much more planning and documentation before detailed design and construction can be accomplished. Even at this early stage of the project, habitat development appears feasible both in the Trinity River Basin and Trinity Bay.

South of Wallisville Lock and Dam

265. According to information furnished by the Fort Worth District, approximately 5 million cubic yards of dredged material is to be removed from the area below the Wallisville Dam, located above the Old River Cutoff west of Lake Anahuac, for the Trinity River channel. Much of this material will be from virgin cuts, especially in the open water of Trinity Bay. The sediments, according to the best available information, are uncontaminated to slightly contaminated and

consist of silty sand. The rest of the material will be dredged from the existing river and be slightly or moderately contaminated with non point-source chemicals or be dredged from a shoaled-in channel adjacent to the mainland south of the town of Anahuac (Figures 36 and 37).

Marsh area

266. In the brackish marshes of the Trinity River delta below Wallisville Dam, environmentally acceptable disposal alternatives are limited. Since the marsh west of the river consists of high quality undisturbed gulf cordgrass, no disposal sites have been planned in this area. On the east side of the Trinity River, where the marsh is fresh and consists mostly of waterhyacinth in disturbed substrates between two levee systems, a disposal site large enough to hold all or most of the initial dredged material from that segment of the Trinity channel is planned. Construction of this site located between the levees will allow what seems to be the only practical method of disposal in this area.

267. It is recommended that the sandy sediments to be placed in the disposal area should not be confined, as the sand will rapidly settle out. Should a dike be deemed necessary after further assessment and input from interested agencies in response to the Environmental Impact Statement, the construction of a temporary earthen or sand dike around the site would effectively hold the material. Since the material to be dredged is primarily sandy, mounds inside a dike could be created without the necessity of a high dike (over 8 feet), and the dike could be breached if necessary after dewatering to prevent isolation of the newly formed habitat from neighboring areas.

268. The projected placement of approximately 14 feet of dredged material inside the undiked disposal site would ultimately result in a large upland area offering potential for upland habitat development and creating an area of diverse habitat unique and beneficial to the area. The Trinity River delta is heavily used by waterfowl, marsh birds, and colonial waterbirds for feeding. If a dike is built around the disposal area in the marsh, a stillwater internal pool will result that will

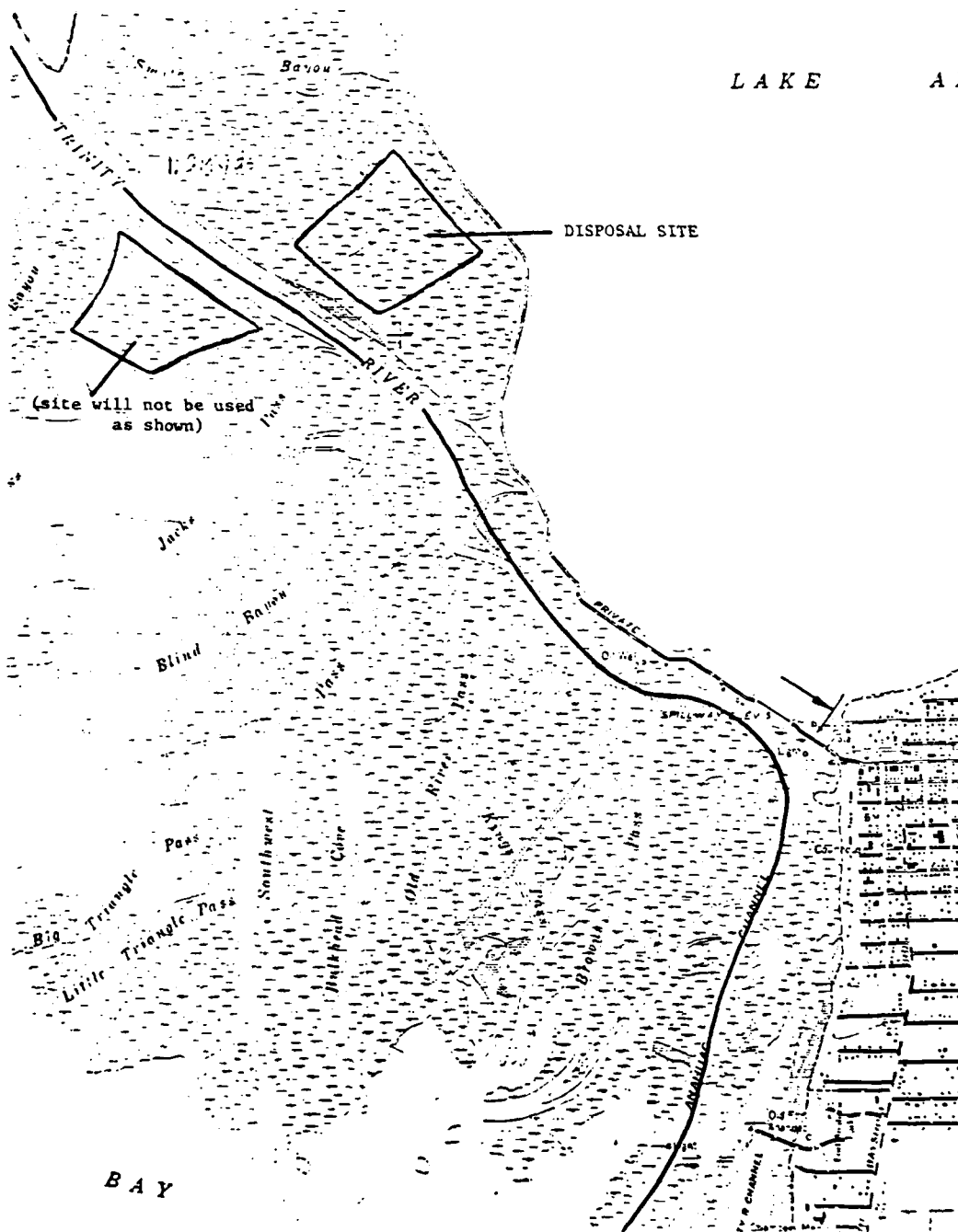


Figure 36. Marsh disposal site south of Wallisville Dam

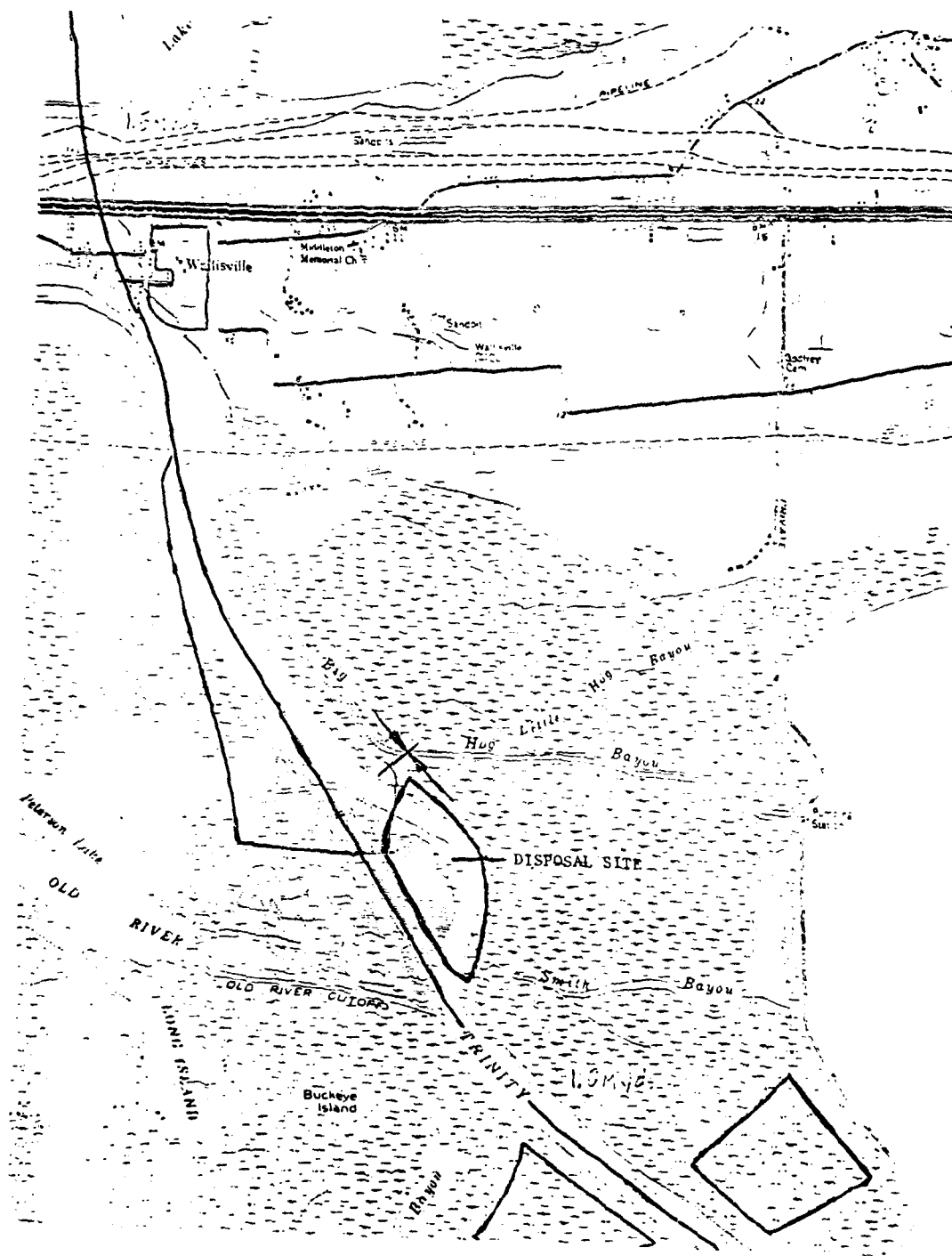


Figure 37. Disposal sites at Wallisville Dam and below

temporarily create feeding areas for these avian species. Studies in other diked disposal sites (Parnell et al. 1978; Scharf et al. 1978) have shown that temporary pools inside dikes have been heavily used for waterfowl and shorebird feeding.

269. A temporary pool inside a dike may cause possible problems with mosquitoes, which may be remedied by treating the pool area with larvicides or by draining or maintaining water levels in the pool (Ezell 1978). The potential problem will be alleviated once the site is filled with dredged material. It should be noted that any such treatment of pools with larvicides not only reduces the mosquitoes, but the feeding bird population as well (Parnell et al. 1978). Other potential objectional environmental conditions with diked areas are discussed by Harrison and Chisholm (1974).

270. Once unconfined dredged material is placed on the site, an upland area consisting of primarily sandy substrate will be created. This area will be difficult to revegetate if it is similar to other existing disposal areas in the Trinity River basin where the dredged material is mounded too high for plants to be able to reach the water table, thus eliminating natural colonization.

271. Ideally, this upland "island" should be developed to provide wildlife with a change of habitat that could be used by deer and other upland mammals, by songbirds, and possibly as nesting habitat for colony nesting waterbirds that may be displaced by the disposal site nearer Interstate 10. Placement of the dredged material to allow formation of a series of mounds and valleys would be better for wildlife purposes than a uniform placement of dredged material. Uniform placement would probably result in little vegetation colonizing the site and create a wind erosion problem as well. Uneven terrain would allow maximum shelter for seeds and vegetative propagules brought in by various sources and allow natural colonization to take place. It would also allow maximum protection and success of planted sites such as spot plantings of grasses and trees.

272. Suggested plantings of an area near the coast in uneven sandy terrain are native grasses and herbs such as Texas bluestem, southern

dewberry, and a variety of other suitable species listed and discussed in CZRD (1978), Hunt et al. (1978), and Landin (1978a) for the higher sandy mounds. Mann et al. (1975) gives recommendations on landscape and terrain development. If the elevation is so high that plants would have problems reaching the water table, two approaches--planting dune grasses or bulldozing the mounds to a lower elevation--may be taken. These sites should be anticipated as needing fertilizer to allow maximum success of plantings, and continued periodic fertilization may be necessary. The lower valleys or depressions in the dredged material may be planted with fresh water species known to tolerate moist to wet sandy conditions such as black willow, water oak, eastern cottonwood, tamarisk, and Chinese tallow. Legumes such as clovers and lespedezas would be beneficial since they would provide their own source of nitrogen and help provide nitrogen for other planted species. Since some sedges and nutsedges naturally occur on similar sites in the Trinity River basin, these may be introduced to the site in both valleys and upland areas, with the species varying according to their tolerance to drought. More detailed discussion of terrain contours is presented in paragraphs 275, 292, 293, and 294 in Part VI.

273. A short-term pilot study is recommended to ensure highest establishment success rates. It should be designed to determine if plants will grow on the dredged material at the projected elevations and what species will survive and reproduce best. Such parameters as survival, vigor, reproduction, biomass, and contaminant uptake could be measured in a small-scale study before the larger project is undertaken. The pilot study may be conducted either by growing plants at various moisture levels in dredged material from the channel in a greenhouse study or by growing plants on small selected areas of the actual disposal site as soon as possible after the dredging phase is complete. The field plan has the advantage of being less expensive and will allow for more species to be tested; the greenhouse study, while expensive, can be conducted at any time of the year and will give plant propagule success data before the dredging project is undertaken.

274. When the disposal site is planted, it is suggested that several species of grasses, legumes, and herbs be planted in mixtures at higher elevations and that several tree species and understory plants (sedges, herbs, and shrubs) be planted in valleys to ensure maximum cover and stabilization of the substrate in the shortest period of time.

275. If a dike is built but is not filled to its height at initial dredging and the disposal site is not slated for continued maintenance dredging, the dike should be breached or lowered to the same elevation of the dredged material deposit to prevent standing water on water-logged soils. A properly designed weir may be effective for maintaining water drainage. This situation would most likely result in the volunteer establishment of a dense stand of common reed to the detriment of any planted species and the loss of quality habitat.

276. Tamarisk, willows, and other small tree species have been found to be used for nesting by colonial nesting waterbirds in the Trinity Bay and Galveston Bay areas. A colony of nine different species of herons, egrets, and cormorants nested on an old Trinity River channel dredged material island in 1977 (Chaney et al. 1978), and all were nesting in tamarisk. Several other of these islands also contain nesting colonies. The Trinity River basin south of Liberty historically has been used by colonial nesting birds; their new-found habitat (the dredged material islands created by the dredging of the old Trinity River channel) is eroding away and the Interstate 10 colony is being displaced by a disposal site. Thus, creation of suitable nesting habitat would be highly desirable.

Open water area

277. In the open water area shown in Figures 38, 39, and 40, material from an 8-foot cut would have to be placed. Several alternatives for this new material exist:

- a. Build a single, large, super island in Trinity Bay adequate for holding all of the dredged material.
- b. Build several smaller islands or add to existing small dredged material islands in Trinity Bay for habitat diversity, to increase productivity of a somewhat sterile

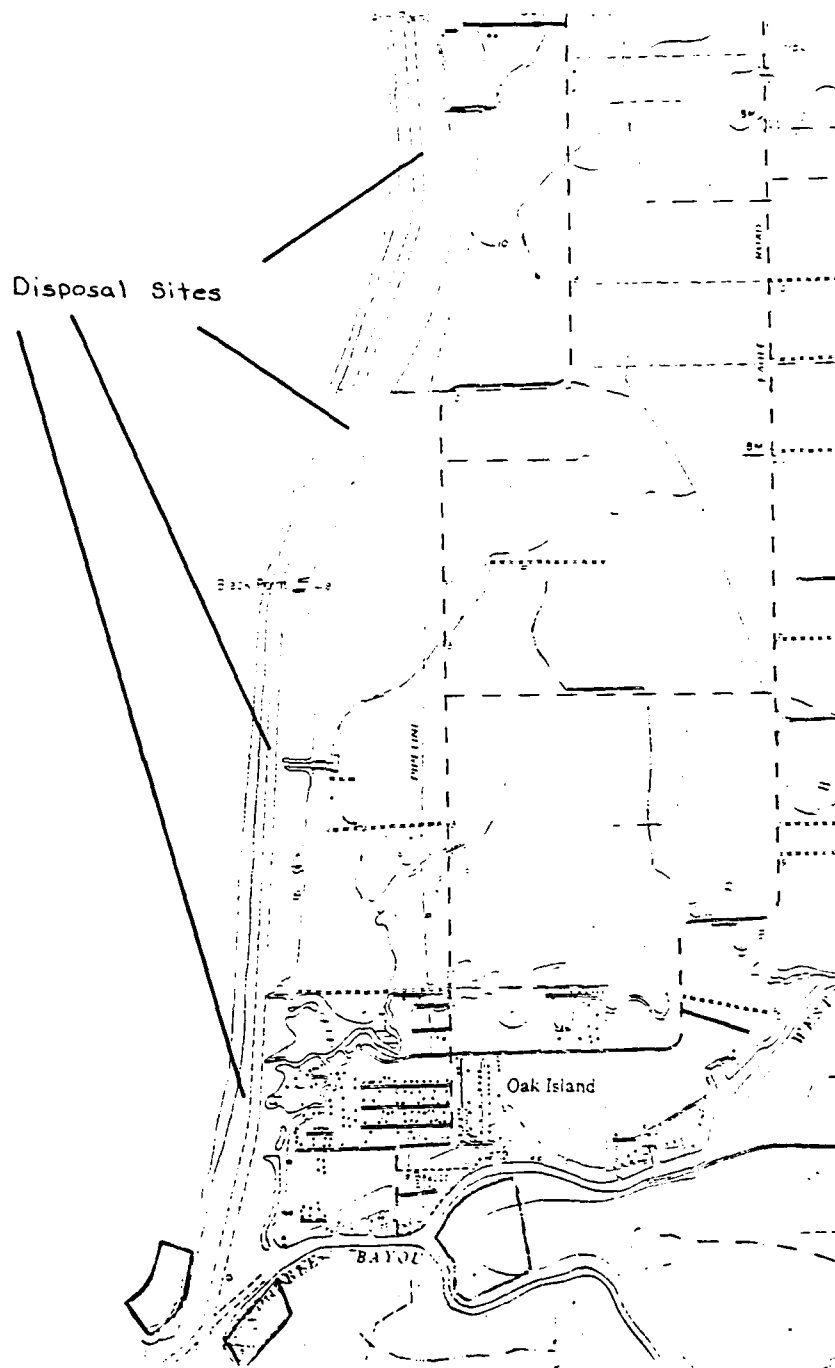


Figure 38. Disposal sites along old Trinity River Channel

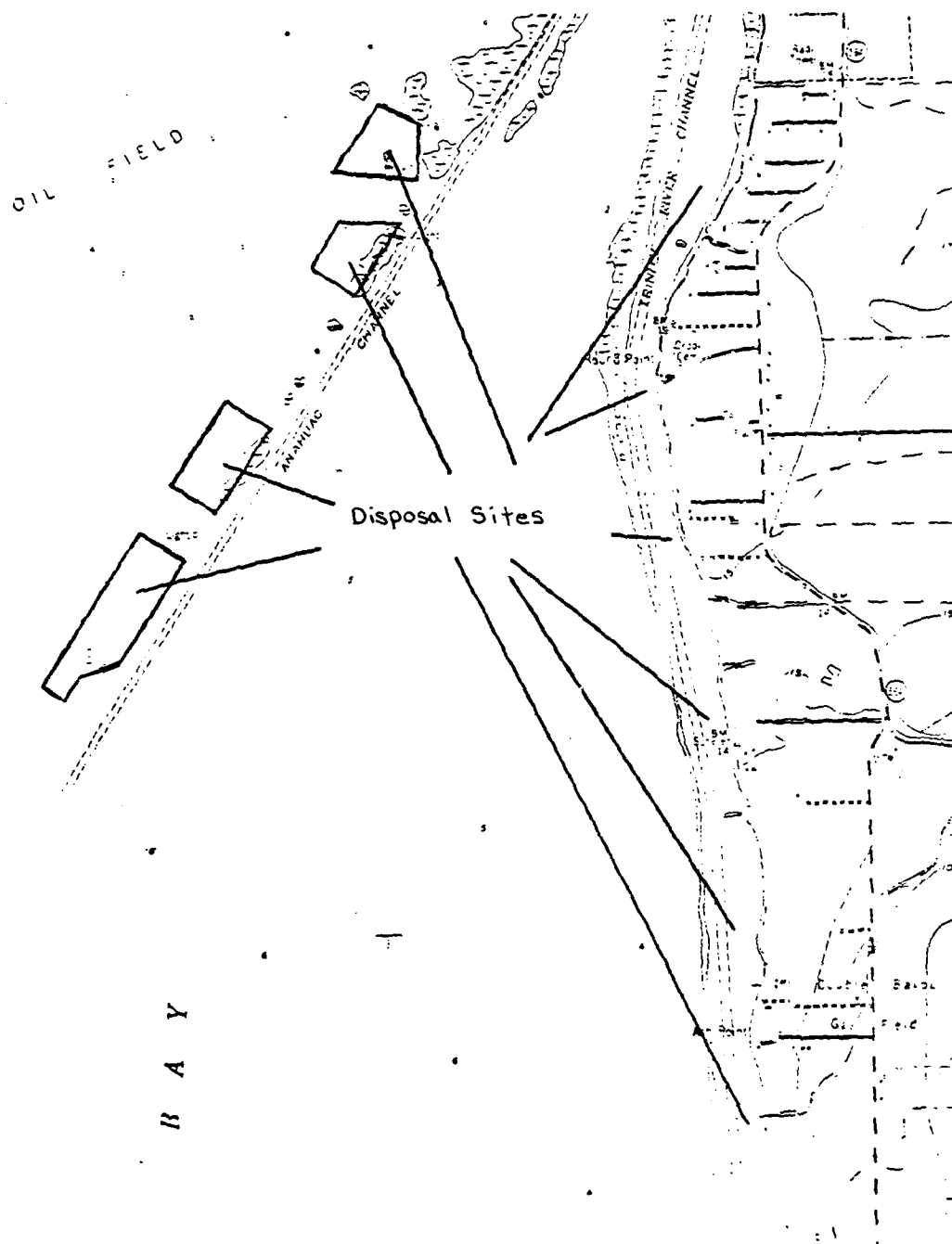


Figure 39. Disposal sites along old Trinity River and old Anahuac Channels

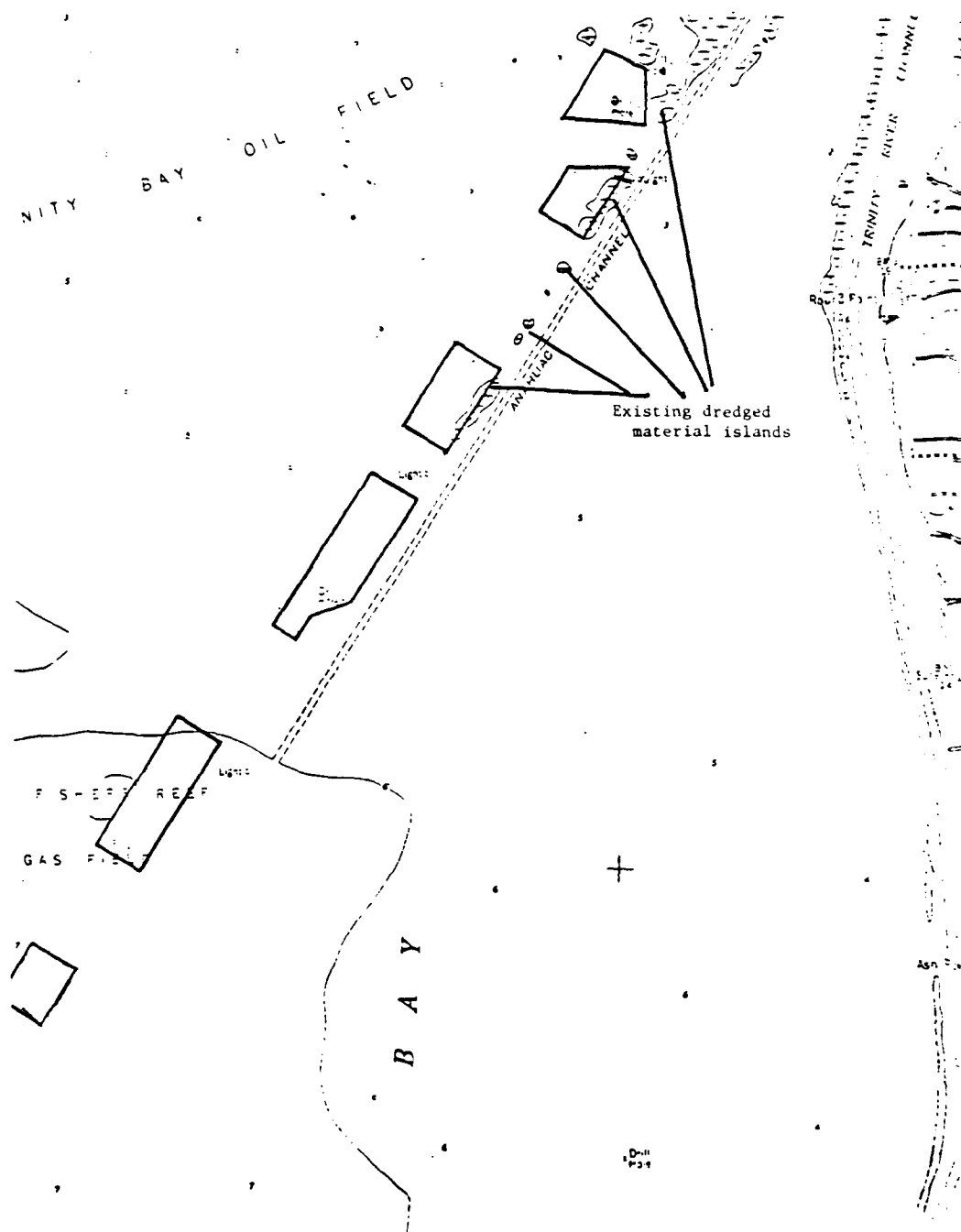


Figure 40. Existing dredged material islands in the Anahuac Channel that can be used for placement of dredged material

area, and to provide habitat for colonial nesting waterbirds that is presently scarce in the Trinity Bay area.

- c. Pump material inside dredged material banks into the old Trinity River channel adjacent to the mainland south of the town of Anahuac.
- d. Pump material onto the upland mainland into an area of currently unknown habitat.
- e. Raise the bottom level of the deeper parts of the bay and provide attachment bases in the new site to encourage benthic diversity and colonization.
- f. Any combination of the above.

278. Super island. The creation of a large 100- to 300-acre disposal island in an unproductive area of Trinity Bay near the proposed shipping channel for the purposes of holding all of the initial dredged material has precedents in other shipping areas (Scharf et al. 1978; Soots and Landin 1978) and is practical as well as beneficial to certain species of wildlife. An island such as this would be similar to two diked super islands built in Lake Erie by the Detroit District that were not constructed for purposes other than disposal of large quantities of dredged material, but that now have also found use as nesting and feeding habitat for seabirds and herons. The Trinity Bay island could be designed for use both at initial project construction and for future maintenance dredging.

279. Available information indicates that the dredged material in Trinity Bay is silty sand of a very fine texture. It is likely that a structure to retain this material would be necessary, but the dredged material itself probably would be too fine for use as dike construction material. Suitable dike material would have to be obtained and transported to the site. Eckert et al. (1978) gives recommendations for dike construction, possible problems, and costs of dikes; Murphy and Ziegler (1974) discuss present day practices and problems encountered in confined disposal operations.

280. If a dike must be built, the prospects for habitat development within the dike would depend upon the elevations of material after each dredging period and the ultimate elevation of the site. Following dike construction, and during and immediately following

initial dredging, the interior of the site could predictably be used as a temporary safe stillwater feeding area for waterfowl and other birds unless the overall elevation is above water. If the area remained submerged for a year or longer, aquatic plants that are relished by waterfowl, such as widgeongrass and slender pondweed, could be introduced to the ponded area.

281. If elevations inside a dike are at marsh elevation (i.e., shallow or patchy standing water), marshes would probably form by natural colonization and succession, but not necessarily by desirable plant species. To ensure that marshes of value are formed, the planting of such species as arrow arum, arrowheads, bulrushes, and sedges should be undertaken. Salinity and soil type play an important role in species selection at this point. If the site is more saline than existing information indicates, then salt marsh species such as saltmarsh bulrush, saltmeadow cordgrass, and saltgrass should be planted instead of the previously mentioned freshwater species.

282. If the site reaches upland elevations, it may be planted with a variety of Texas coastal plants such as groundsel tree, salt cedar, toothache tree (Chaney et al. 1978; Soots and Landin 1978), or be allowed to colonize naturally. Natural colonization is known to be fairly rapid in the Galveston/Trinity Bay area, as well as in the Houston Ship Channel. These species are coastal climax plants and should be used with the intention of establishing them as the ultimate vegetation on the upland site. Outside the dike, a fringe of gently sloping substrate should be formed and planted with smooth cordgrass to help stabilize the area. This marsh can be formed by lowering a temporary dike.

283. It should be noted here that in several areas of the United States coastal waterway system large dikes are used successfully by colonial seabirds such as gulls, terns, and skimmers for nesting (Chaney et al. 1978; Parnell et al. 1978; Scharf et al. 1978; Soots and Landin 1978), and that habitat for these particular species is scarce along the northern Texas gulf coast (Chaney et al. 1978).

284. The construction of a very large, unconfined island would be similar to those built in the Laguna Madre and near Aransas National Wildlife Refuge in south Texas with the exception that it would not be located near the mainland. Such an island would become naturally vegetated with propagules from upland plants in its interior and marsh plants on its fringe over a period of time. However, to ensure the establishment of desirable plants likely to create quality habitat, planning should be undertaken. If, after further sediment tests to determine texture and stability, it is judged to be feasible to construct an undiked large island, the recommendation is that an undiked island is the better of the two possibilities because it will allow more interaction between island interior areas and the bay area by wildlife.

285. The contours of the undiked island should be gently sloped to an intertidal level either during dredging by movement of the dredged pipe or by heavy equipment after stabilization. Mid and lower intertidal areas should be planted with smooth cordgrass; upper intertidal areas should be planted with saltmeadow cordgrass and saltgrass (see Environmental Laboratory (1978a) for these details). Marsh grass species have been shown by numerous researchers to be highly productive stabilizers of salt marsh sediments; in addition, propagules are available from local sources.

286. The upland interior of the large unconfined island should consist of a series of mounds of dredged material to create a diversity of habitat. This uneven terrain will aid in establishment of plant propagules. As with the marsh disposal site previously discussed, native coastal grasses such as Texas bluestem, coastal Bermuda grass, and others should be planted on dry higher areas, with trees such as toothache tree, groundsel tree, salt cedar, and marsh elder planted in intermediate areas with a greater water supply.

287. One feature which would be an asset to a large island is the placement of the dredged material to create a permanent pond area in the island's interior. Such a fresh, slightly brackish pond would be heavily used by wildlife and would increase the probability of wildlife

colonizing the island. The pond should be shallow (less than 10 feet deep) and less than 5 acres in size; more than one small interior pond on the island could also be established.

288. Small islands. An alternative to a large island is a series of small islands less than 50 acres each in size. Examples of similar islands are those built by the Wilmington District in Core Sound in North Carolina for seabird nesting (Soots and Landin 1978). The purpose of these islands would be to create sites for nesting waterbirds that were predator-free and of sufficient elevation to provide safety against tides and floods. In addition, migrating birds are likely to use adjacent shallows for feeding. These islands have several disadvantages:

- a. U. S. Fish and Wildlife Service and National Marine Fisheries have indicated to the Fort Worth District that they are opposed to islands even though they will not cover existing productive bay-bottom habitat.
- b. They may hamper water circulation in the bay unless carefully placed.
- c. They will erode more rapidly than the larger island.
- d. There is no absolute guarantee that any of the islands will be used by colonial waterbirds as nesting sites.

289. The series of dredged material islands along the old Anahuac channel in Trinity Bay which are eroding could be enlarged and stabilized by the placement of dredged material adjacent to the existing islands. Both new and existing islands could be planted with a fringe of smooth cordgrass, saltmeadow cordgrass, and saltgrass to stabilize them and provide productive marsh areas.

290. The old Trinity River channel. An alternative under consideration by the Fort Worth District is to pump the initial dredged material and/or routine maintenance dredged material into the old shallow, nearly filled Trinity River channel behind the dredged material bank created many years ago by the building of this first channel (Figures 38-40). Several possibilities exist here. First, initial dredging of a new channel would undoubtedly fill this site to a high marsh/upland elevation that would require stabilization by coastal upland plant species if all of the proposed dredged material was placed there.

Second, the area could be developed as a marsh if only part of the dredged material was placed in the old channel. To do this, the dredged material would require grading after dredging was completed to remove high spots and to ensure that the substrate was at an intertidal level. Then the new area would have to be planted with smooth cordgrass at the marsh's fringes with saltmeadow cordgrass, saltgrass, and gulf cordgrass planted above the smooth cordgrass zone.

291. Third, a good possibility for habitat development in this area would be the creation by careful placement of dredged material of a diversified habitat which could include shallow tidal pools, intertidal pools, and upland areas (Figure 41). Such interspersed habitat types would provide for maximum wildlife use of the area. Careful design and placement of the material would allow the channel to be filled in segments. The marsh and upland areas should not be allowed to colonize naturally, as a ready propagule source of common reed already exists on the existing dredged material banks. A concerted effort to prevent the common reed from taking over any upland site would be necessary, and the planting of other species of a competitive nature such as groundsel tree and the changing of elevation would help prevent this. The intertidal areas could be planted with saltmeadow cordgrass and smooth cordgrass; the upper marsh edges should be planted in gulf cordgrass. Propagules of all these species are readily available in the immediate area (Chaney et al. 1978; Blanton et al. 1978) and propagules for planting the site would be no problem. In general, propagules should be planted on three-foot centers, but faster cover could be provided by more dense plantings.

292. In the more northern reaches of the old channel, dredged material could be planted at intertidal levels with saltmarsh bulrush, big cordgrass, saltgrass, and saltmeadow cordgrass as well as gulf cordgrass on the edges of the intertidal area. These plants should be used only if a brackish influence on the site does not exceed 10 ppt.

293. Mainland disposal sites. The building of large unconfined disposal sites on upland areas of marginal value is another alternative under consideration. While it probably would not be necessary, should

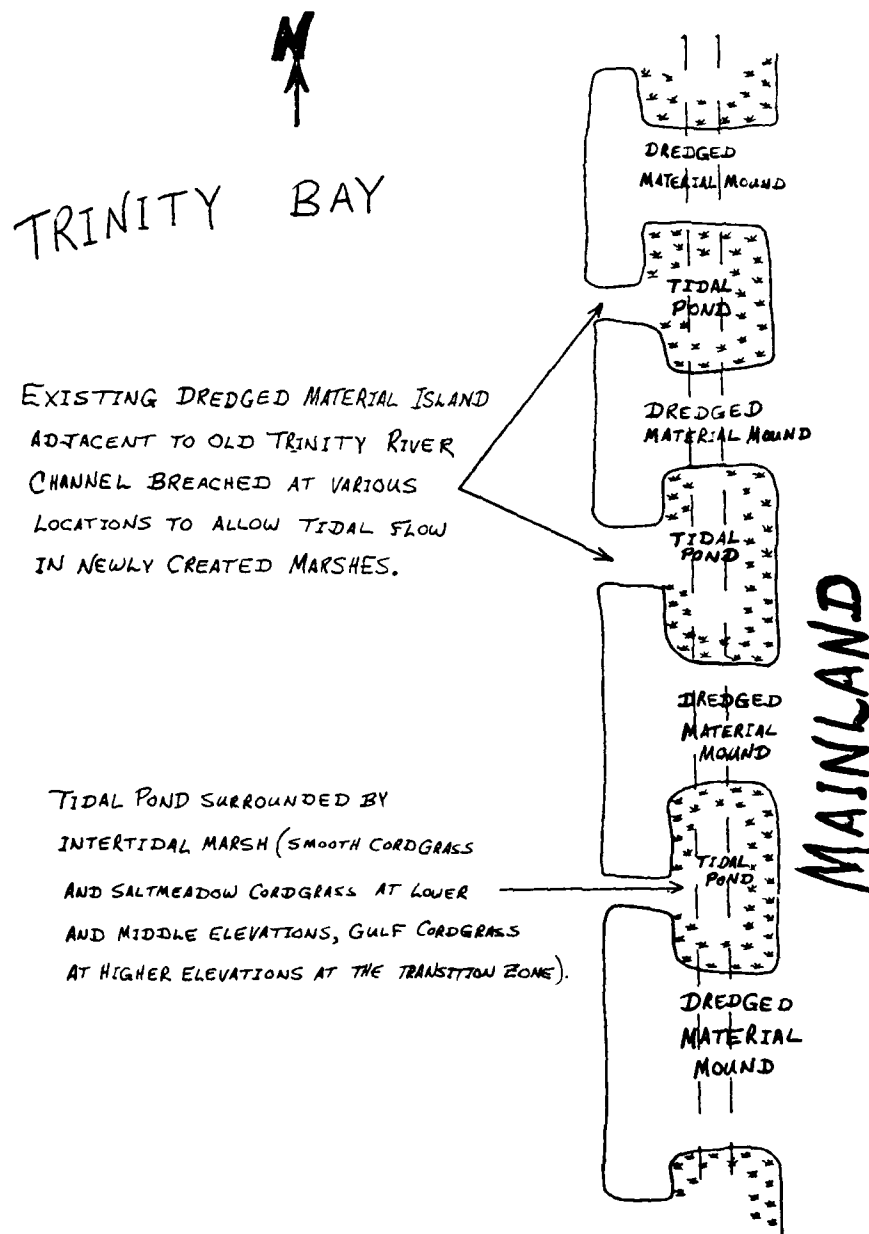


Figure 41. A sketch showing placement of dredged material in the old Trinity River Channel (parallel broken lines) to allow maximum habitat diversity

the planting of vegetation be required on these upland sites, the same vegetation succession stages for sites previously discussed would apply here. Use of such disposal areas would provide an alternative to "no island" creation, but would require that the dredged material be moved much greater distances from the dredging area (channel).

294. Baybottom disposal. Dredged material could be placed at a depth of 1-3 feet below low tide elevation at unproductive bay-bottom locations. The purpose of this placement would be the encouragement of shellfish recolonization in Trinity Bay. Historically, the bay had highly productive oyster reefs prior to the discovery of oil. The possibility of shellfish reestablishment would require additional study and careful placement of the dredged material. It would also require placement of objects such as rocks, boat hulls, old tires, or other durable material to give the oysters a place to attach. A growth inhibitor prevalent in all lower Trinity River waters is derived from an unknown source and is likely to have an effect on not only shellfisheries, but vegetation establishment as well. The phenomenon is too poorly understood to predict its effect on any habitat development efforts, but the Trinity Bay area is now devoid of seagrasses and oyster reefs.

295. Combination of the alternatives. The most workable and productive approach to the disposal of 5 million cubic yards of dredged material would appear to be a combination of the alternatives discussed. For example, likely approaches could include the building of one super island and a series of smaller ones at acceptable sites or the putting of the initial dredged material in either the super island or in mainland sites with material from routine maintenance dredging placed in the old Trinity River channel (Figures 38-40). The placement of all the material in the old river channel is the plan presently favored by the Fort Worth District. Routine maintenance dredged material would then be placed in other locations such as one mainland site or on existing islands to slow down the erosion of those islands, especially ones with nesting colonies of waterbirds. Establishing one or two benthic enhancement sites as part of an overall plan would allow

testing and data collection on this alternative to determine its practicality in Trinity Bay. If it appears to be succeeding, other sites could be established with routine maintenance dredging.

296. From a standpoint based on economical and environmental considerations and the value of the created habitat, it is recommended that the combination of alternatives placing some of the initial dredged material in a series of deposits in the old Trinity River channel and adding dredged material to the existing islands off the Anahuac channel for the remainder of the initial dredged material be used. Maintenance dredged material could be used to create various stages of succession of vegetation as described in Soots and Landin (1978) by placing the material on either the old channel site or on existing islands. This combination of alternatives would also provide the least impact to existing habitat and avoid the need for creation of a new island site which would probably meet with objections from fisheries interests.

Wallisville Dam North to Liberty

297. A large, undetermined amount of dredged material in excess of 7 million cubic yards would be removed north of Wallisville Dam. Most of this dredged material would be from virgin cuts, especially in the area of Interstate 10 (Figure 42) and north of Wallisville Lake where most bends and curves in the river would be straightened and removed (Figures 43, 44, and 45). This large volume of dredged material, from best available information, seems to be semipermeable clays underlain with sand. Hydraulic dredging of this material would result in a mixing of these soil types resulting in a primarily sandy dredged material.

298. Since the areas adjacent to the Trinity River and in the Trinity River floodplain are for the most part high-quality wildlife habitat consisting of bald cypress swamps and freshwater marshes, disposal site selection in this area is a sensitive matter. Elimination from consideration of the oxbow areas created by the bypassing of river bends and the swampland areas is a reflection of the concern for wetland

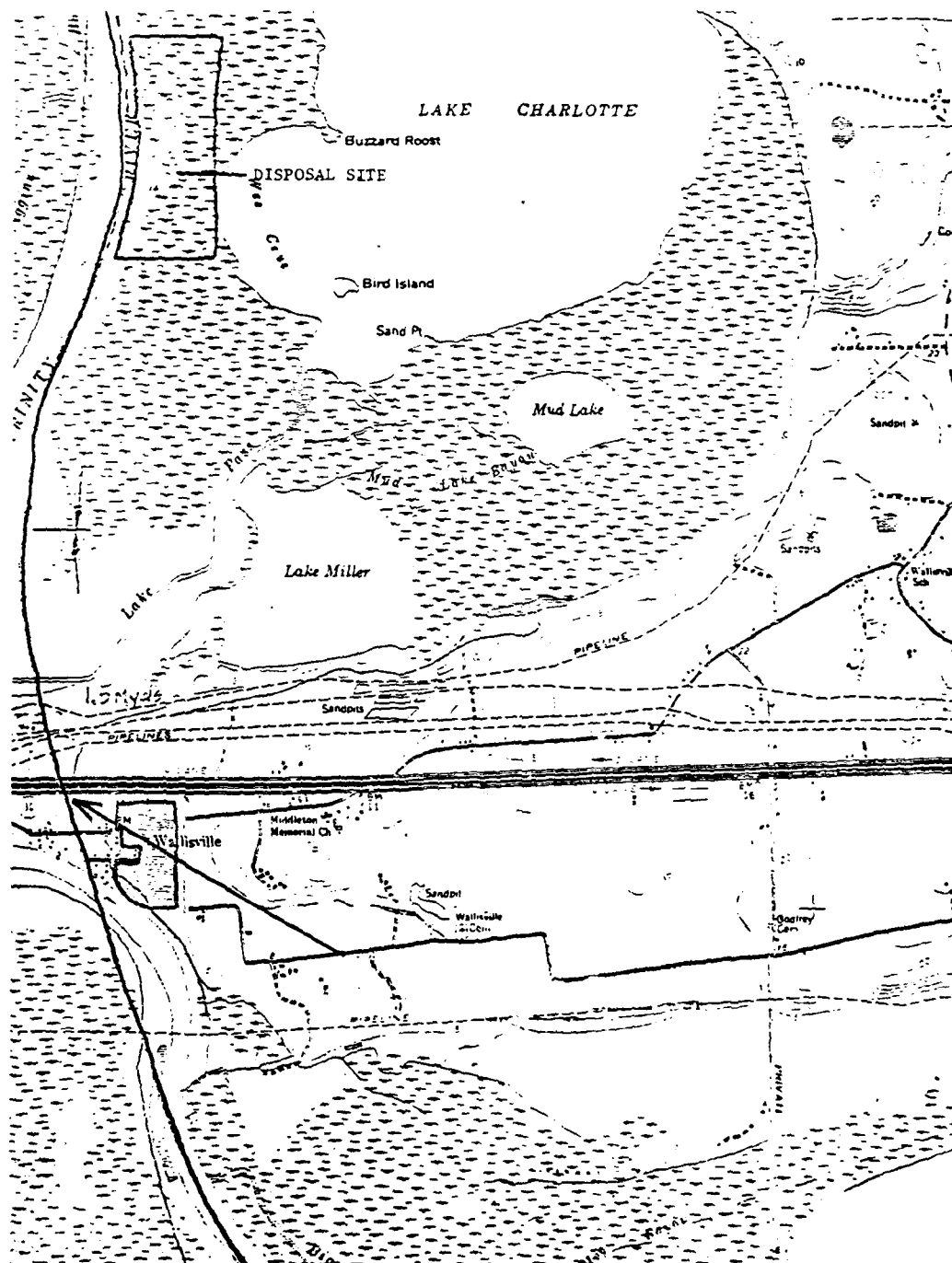


Figure 42. Proposed channel of the Trinity River project showing cut where a new interstate bridge must be built

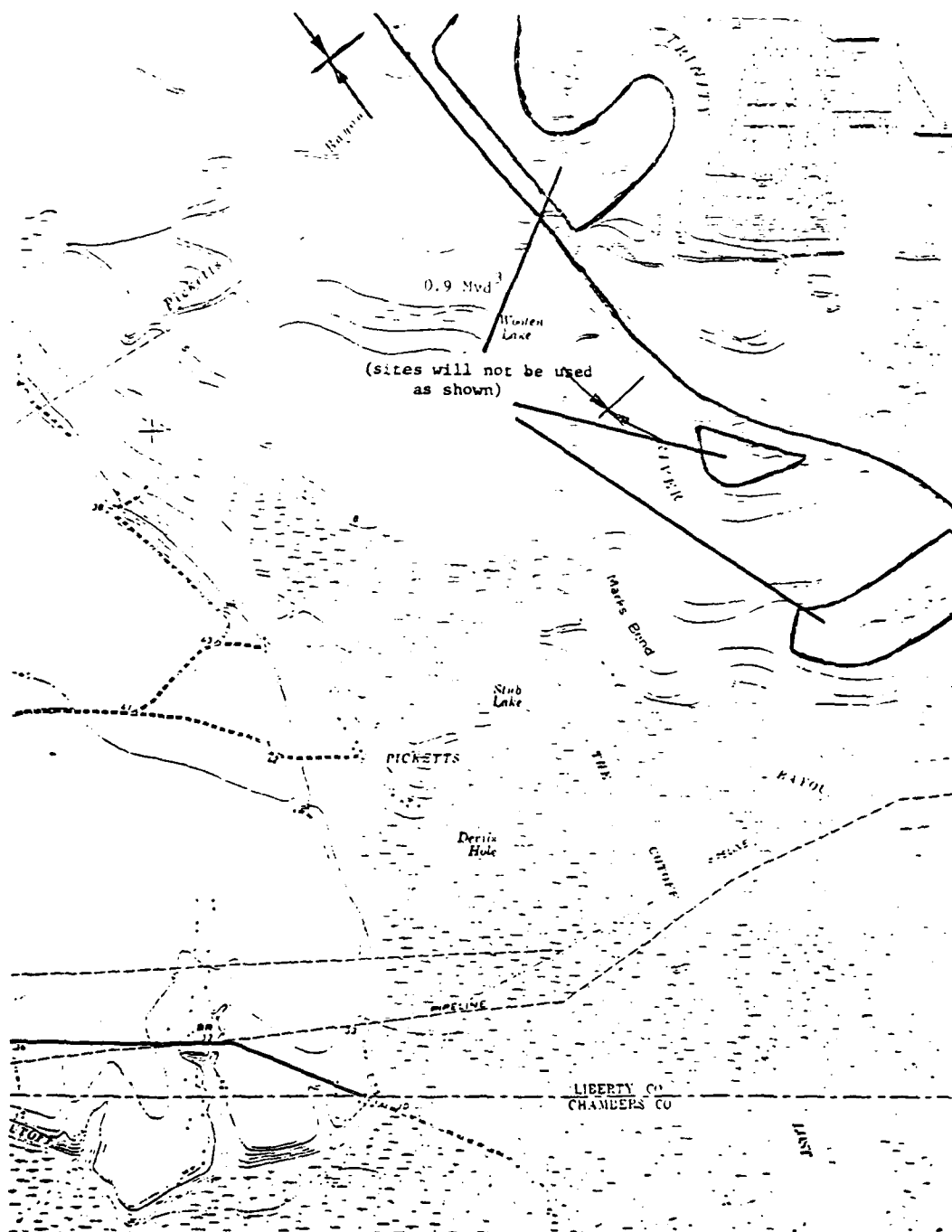


Figure 43. Proposed channel of Trinity River project

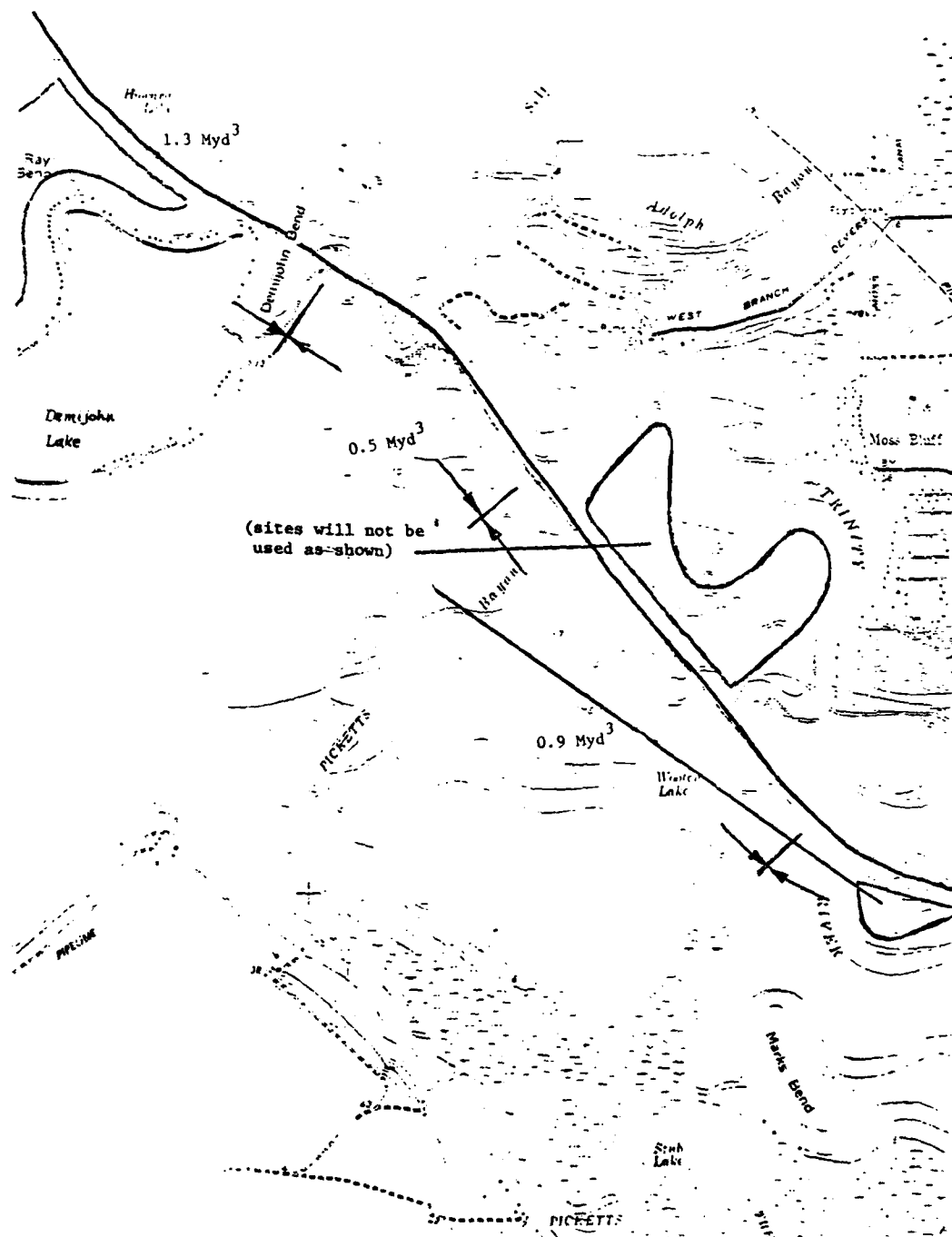


Figure 44. Proposed channel of Trinity River project

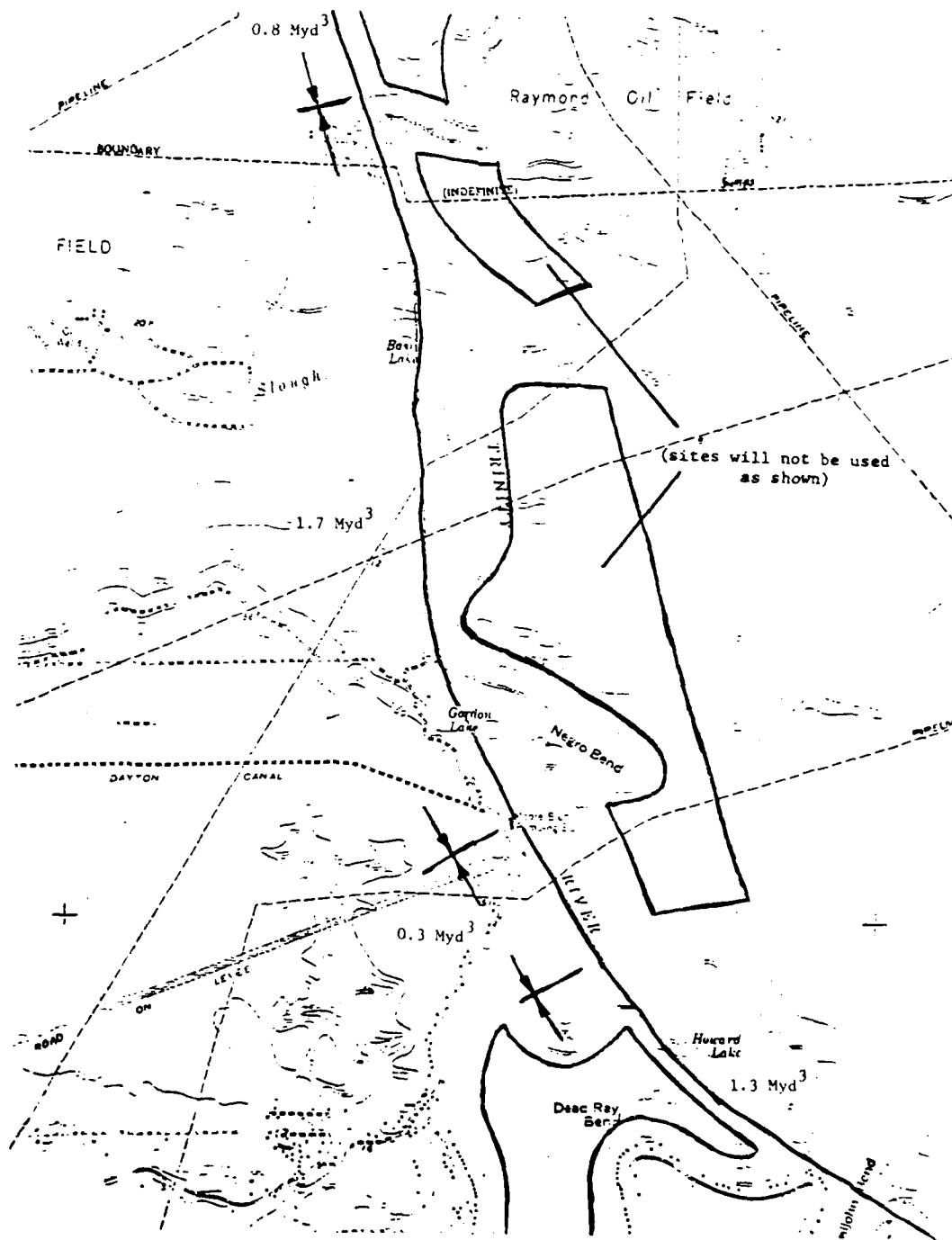


Figure 45. Proposed channel of Trinity River project

preservation. The relatively few sites that have been selected are projected by the Fort Worth District as adequate for storage of all the initial dredged material and are mostly in disturbed areas.

299. One site that would be likely to cause some problem is the disposal site immediately south of Interstate 10 (Figure 46). A large mixed heronry is located in tall cypress trees on the site and although the trees will be left standing and the heronry not immediately impacted, when the trees subsequently die and fall over a period of years, the heronry will have to move. Only if new trees can quickly reach adequate size for nesting birds at a higher elevation on this dredged material would the waterbirds be able to remain.

300. The proposed disposal areas are large (several hundred acres in size) and would probably not have to be diked. The islands created amidst the cypress swamp area by placement of large volumes of dredged material will offer habitat diversity for wildlife.

301. The sites, which are wooded to some extent, could be disposed upon as they are or the timber could be selectively harvested (in most cases, clear cutting is not recommended). If the disposal area is not logged, the disposal of the dredged material would eventually kill most of the existing trees. Standing deadwood provides useful habitat for many wildlife species by offering foraging areas for some species (i.e., woodpeckers) and shelter for others (i.e., cavity-nesting birds and denning mammals). If the disposal area is selectively cut, leaving behind hollow trees and existing deadwood, essentially the same effect could be achieved with the added benefit of harvesting the usable wood. Clearcutting would permit timber harvest without real benefits to local wildlife.

302. As the sites are filled with dredged material, several options for habitat enhancement present themselves. One large mound could be created to form a gently sloped hill in an otherwise flat area of the country. This mound could be planned for upland forest or agricultural land or, if located near road access, as a recreational site; however, nonwildlife use of such sites would face strong opposition from interested agencies and groups.

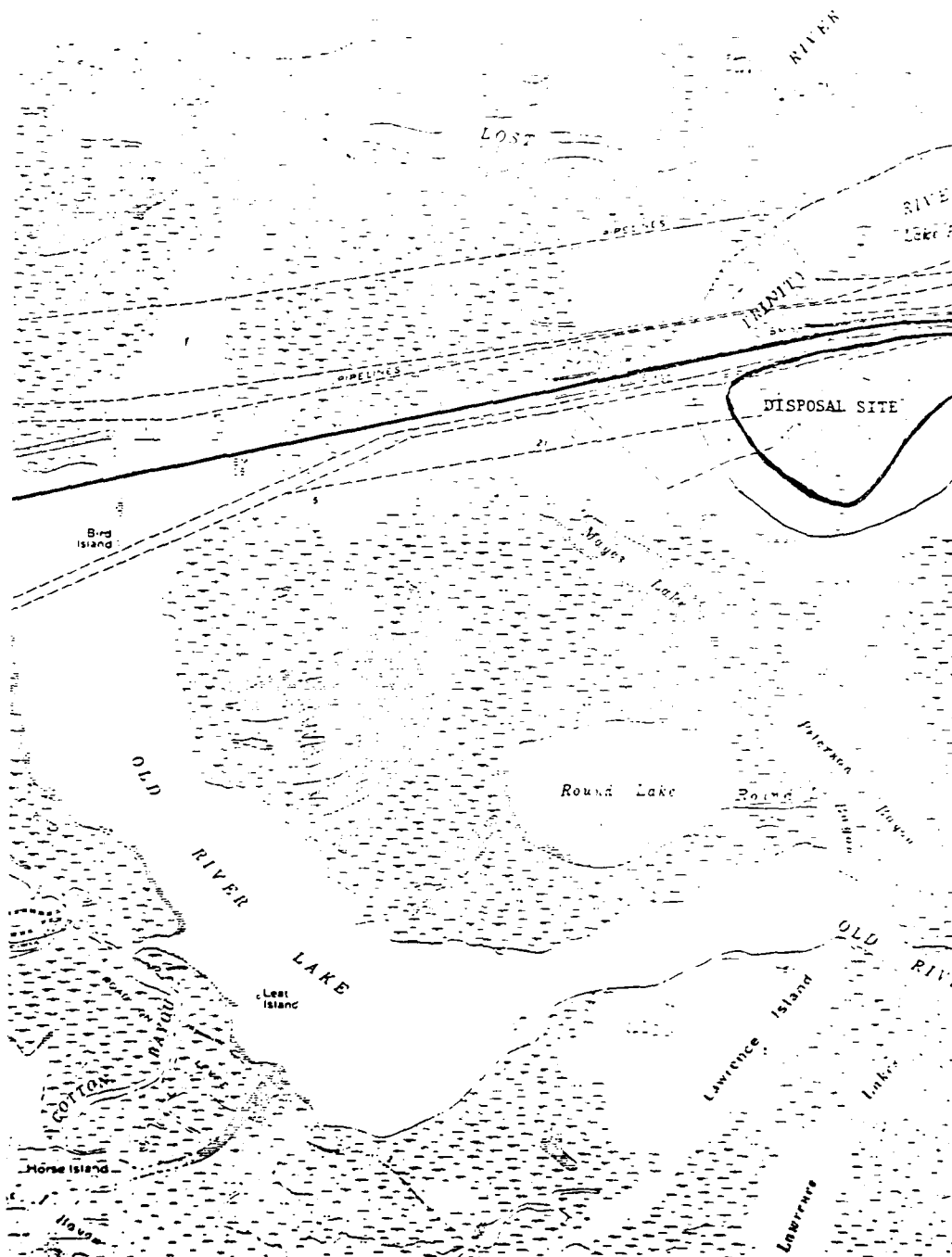


Figure 46. Disposal site where large heronry is located south of Interstate Highway 10

303. Multiple mound creation is far more feasible in a large area and also provides a much more diverse habitat for the area's wildlife. This could be achieved by the movement of the dredge pipe as each mound is formed to create a series of mounds and valleys. The valleys would act as silt traps during dewatering of the dredged material and in flood periods on the river; the mounds would consist primarily of sand that had been sorted out in the dewatering process.

304. The formation of mounds and valleys, and thus different habitats, could take several forms, as shown in Figures 47, 48, and 49. Depending upon the desired goal for a given site, random mounds or a series of ridges and valleys may be selected. If the elevation of the material is of sufficient height, three zones of habitat (Figure 48) may be available for development.

305. Two options for revegetating these sites exist. Natural succession depending upon colonization from area propagule sources could be allowed to take place. This is probably not desirable because of the length of time required for natural colonization to vegetate a site, the possibility of pest species vegetating the area, and the sterile sand mounds remaining barren for many years.

306. Planting the sites would be the most efficient way to achieve habitat development goals. Zone planting is recommended. The high, sterile, sandy mounds would be fertilized and planted with Texas and prairie plants such as Texas bluestem, dewberries, and legumes. If sufficient moisture does not exist for such species, a mixture of introduced dry plains or dune grasses might be planted. Seeds are usually best propagules for native grasses, but dune plants survive best when transplants of whole plants or root stock are used.

307. The valleys could be planted with trees such as eastern cottonwood, black willow, green ash, bottomland oak species such as water oak, cedar elm, and Texas sugarberry and a variety of understory plants such as dewberry, frog fruit, ragweeds, and others. Transplants, which allow for faster establishment, are best for the tree species, but understory plants may be either seeded or transplanted.

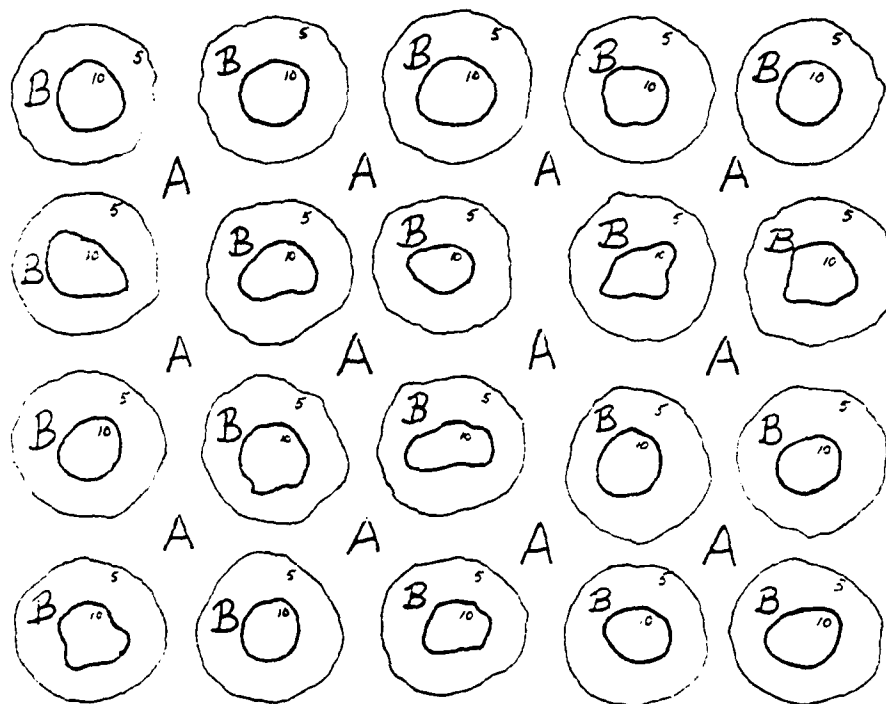


Figure 47. Two habitat types are shown. Type A will occur below the five-foot contour, and Type B will occur above the five-foot contour. Interspersion is achieved by checkerboard arrangement of the mounds

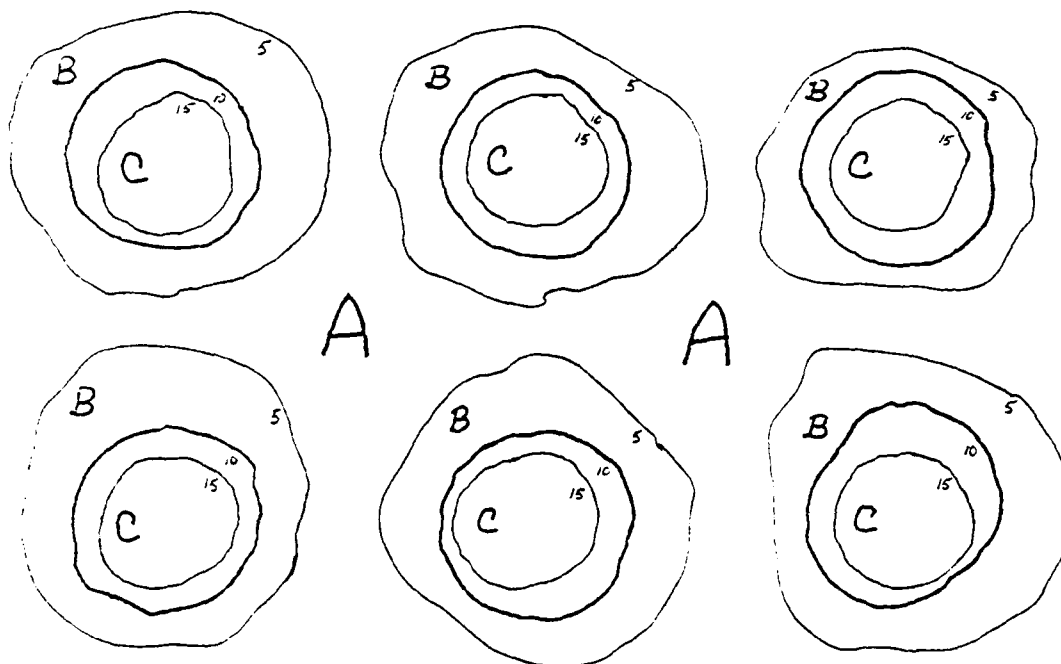


Figure 48. Three habitat types are shown. Type A occurs below the five-foot contour; Type B occurs between the five- and ten-foot contours; and Type C occurs above the ten-foot contour. Interspersion is achieved by checkerboard arrangement of the mounds

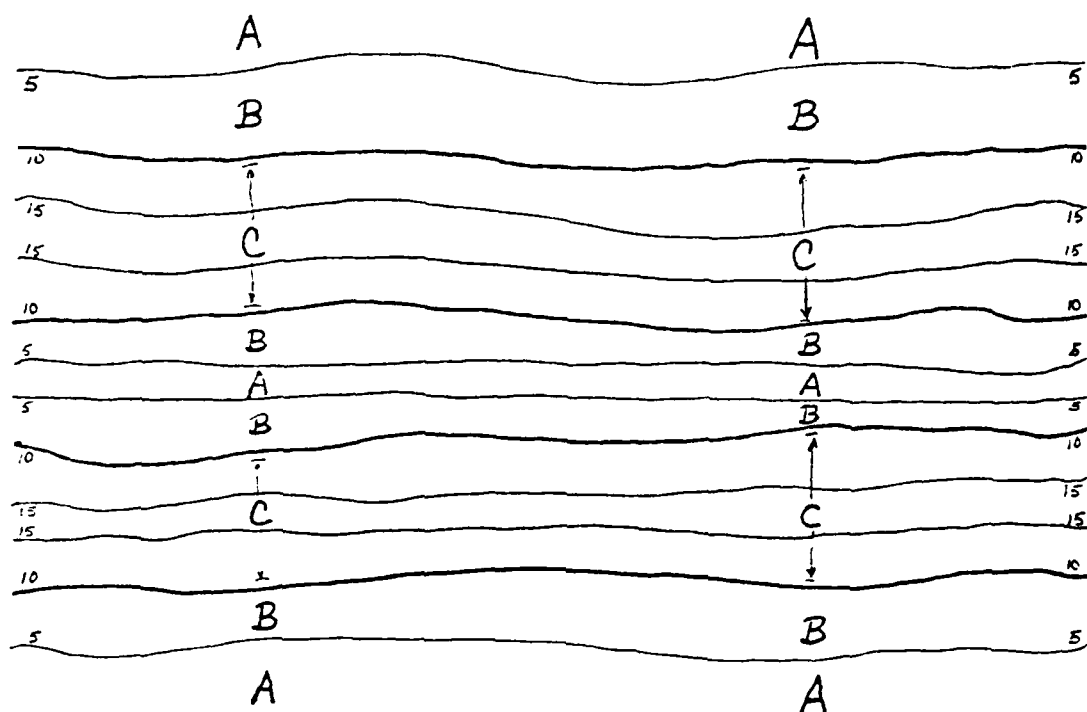


Figure 49. As in Figure 48, three habitat types are shown. Type A occurs at the five-foot contour; Type B occurs between the five- and ten-foot contours; and Type C occurs above the ten-foot contour. Interspersion is achieved by arranging the mounds of dredged material in parallel rows

308. For details on many suitable upland and wetland plant species, refer to CZRD (1978), Hunt et al. (1978), Environmental Laboratory (1978a), Landin (1978a), and Soots and Landin (1978).

309. The transition zone (slopes) between mounds and valleys could be planted with bottomland oak species and more moisture-loving herbs and grasses than those planted on the mounds.

Costs

310. At this time, it is the opinion of the DOTS team that the habitat development aspects of the Trinity River Basin Project can be carried out within the limitations of \$1,100 per acre tentatively established by the Fort Worth District, and on several sites costs would probably be considerably less than that amount (based on 1978 labor and materials costs).

311. More specific information is necessary on each disposal site and the dredged material that would fill it before any more detailed plans for vegetation establishment can be offered. Some general information does apply and can be given at this time.

312. Often tree species such as the ones recommended in this report are available from State or Federal tree nurseries at relatively low cost. Some species such as chufa and many grasses are commercially available from wildlife nurseries and seed supply companies.

313. Harvesting techniques for seeds and vegetative propagules are outlined in detail in Hunt et al. (1978) and Environmental Laboratory (1978a) for those species not readily available. In addition, commercial sources are given. Marsh species such as smooth cordgrass, salt-meadow cordgrass, and others are commercially available from Environmental Concern, Inc. of St. Michaels, Maryland. However, it is always best to use local sources of propagules so that adaptability and success are at a maximum.

314. Planting techniques are also outlined in Hunt et al. (1978) and Environmental Laboratory (1978a). A general rule of thumb for planting vegetative propagules of grasses and herbs is on three-foot

centers. Seeds should be sown at a recommended rate for these species and will depend upon the size and viability of the seed stock.

315. Trees should be spaced at least 10 feet apart and only should be closer when denser cover is desired. Understory plants can be interspersed between the trees to provide protection for the young trees, to stabilize the soil until a young forest has developed, and to provide cover and food for wildlife.

316. Generally, 45-90 manhours per acre should be allowed for digging, preparing, and planting transplants on a site. Seeding labor is less as usually mechanical rather than hand labor can be used.

317. Cost considerations of dike construction around disposal sites should include the costs of breaching or removal of these structures after dewatering.

Recommendations

318. While much more information is necessary before site-specific information could be offered, the general comments in this report will hopefully serve as a basis of discussion and preparation of response to questions raised over the original Trinity River Environmental Impact Statement.

319. Impacts of each disposal site should be weighed carefully and the technical alternative suggestions by WES for island construction and habitat development should be carefully considered to determine political/social acceptance. Perhaps an effort to inform involved agencies of most recent research is needed in order to make way for viable alternatives to placement of the dredged material.

320. Cores of the area to be dredged are needed to determine actual soil types, fertility, and abundance before final habitat development plans can be made. Incidence of pollution as noted in Nixon and Willett (1974) should be investigated and its impacts on dredging and the entire project be evaluated.

321. More investigation into the basic causes of the local growth inhibitor phenomenon is needed before success of a marsh establishment

site or bay-bottom deposit can be predicted. Historic data before the industrialization of the basin took place should be searched to determine if the inhibitor is an industrial-related problem that may be correctable.

PART VII: POTENTIAL HABITAT DEVELOPMENT SITES
IN THE DELAWARE RIVER

by

M. C. Landin

Introduction

322. The Philadelphia CE District (PD) requested assessment by DOTS of potential habitat development sites along the Delaware River that could be established in conjunction with dredging operations. The area of consideration was River Mile (RM) 55-128 of the Delaware River estuary, and included sites under ownership of the States of Delaware, New Jersey, and Pennsylvania, as well as private industry. Lowland, upland, and island sites were examined for their possible use for both marsh and upland habitat.

323. A total of 44 sites were located and checked, including several sites with more than one potential use. There were 33 existing CE and private disposal sites of recent history or present use and 14 sites that are tentatively planned for industrial or other type upland or island development. There were only eight sites located that showed marsh development potential, four of which also had upland and/or island wildlife habitat development potential.

Background

324. Background information was derived from the Delaware River draft Environmental Impact Statement (EIS) (U. S. Army Engineer District, Philadelphia 1975) and from personal communications with Messrs. Bill Mueller, Bob Schmidt, and Jeff Radley of the PD. The PD must dredge 8-10 million cubic yards of sediment yearly to maintain shipping channels in the Delaware River. Most dredging occurs from south of Wilmington (RM 55) to north of Philadelphia (RM 109). This yearly

dredging cycle has been carried out for a number of years, resulting in numerous disposal sites along the riverbanks from Trenton south to Artificial Island at Stony Point. There is usually sufficient channel width and depth beyond Stony Point. Some of the older disposal sites have been used for industrial development and some of the present ones are also slated for industrial or riverfront development.

325. According to the 1975 EIS, the Delaware River is not only burdened by a large silt load, but carries the industrial and municipal waste water for several cities along its route; Philadelphia is the main contributor. The dissolved oxygen level of the river in the Philadelphia area is sufficiently low (around 4 ppm) that spawning by ocean fishes, freshwater fisheries, and other marine life is severely depressed. There are a few beds of aquatic plants occurring north of Philadelphia, but in general mud flats and waters have few benthic organisms and little associated birdlife that feed upon them. Coliform counts are high, especially in summer months.

326. Much of the Delaware River dredged material is classified as contaminated and has varying amounts of lead, copper, zinc, nickel, cadmium, arsenic, and mercury. Metal content reaches its highest point just south of the city of Philadelphia.

327. The salt wedge is creeping about a mile upstream yearly because of urban demands on groundwater and leaching of brackish water into these areas. An increase in salinity of approximately 10 ppt has been noted around Philadelphia in recent years. Salinity levels in the area of consideration range from 10-12 ppt at Stony Point to 0 ppt near Trenton.

328. Natural marsh vegetation from Philadelphia south was once brackish marsh species such as saltmeadow cordgrass which was harvested for hay, but is now primarily common reed. Some freshwater marsh occurs in isolated spots north of Philadelphia. Disposal sites are dominated by common reed after filling.

329. Even though there are great urban and industrial pressures on the Delaware River area and it has been biologically degraded, the potential exists for habitat development and improvement in various places along the river using dredged material deposits.

Sites for Habitat Development

330. The eight potential disposal sites that seem biologically suited for marsh development are:

- a. The shallow cover behind Artificial Island at RM 55.
- b. Reedy Island at RM 55-56.
- c. Salem Cove at RM 59-60.
- d. Pea Patch Island at RM 61-62.
- e. Helms Cove at RM 66.
- f. Chester/Monds Island at RM 83-84.
- g. Darby Creek/Tinicum Wildlife Preserve at RM 86.
- h. Crosswicks Creek at RM 128.

In addition, sites b, c, d, and f offer potential for upland wildlife habitat development that could be built in conjunction with or separate from a marsh.

331. All eight sites have some characteristics in common that will increase the likelihood of a successful marsh habitat development project. They are relatively isolated from heavy industry and are not easily accessible to humans. They are protected from strong current and tidal impacts by virtue of being within a cove, pond, backwater area, or behind an island. With the exception of f and g, they are all either north or south of the most polluted dredging areas, which increases the chances of obtaining less polluted dredged material from which to build a marsh. Four sites are adjacent to an existing freshwater/brackish marsh; dredged material can be used to extend the existing marsh without great difficulty and expense. They are all presently shallow water or mud flat areas.

Artificial Island cove

332. Behind the disposal dike on Artificial Island, a shallow cove exists between the mainland (a natural brackish marsh) and the island (Figure 50). The cove area is approximately 1.25 km^2 . A rise in consolidation elevation from shallow cove to intertidal (mllw/mhhw) would accommodate colonization by saltmeadow cordgrass, common reed, and other marsh species which are prevalent in the adjacent natural high marsh. The cove offers protection from river currents and wind fetch.

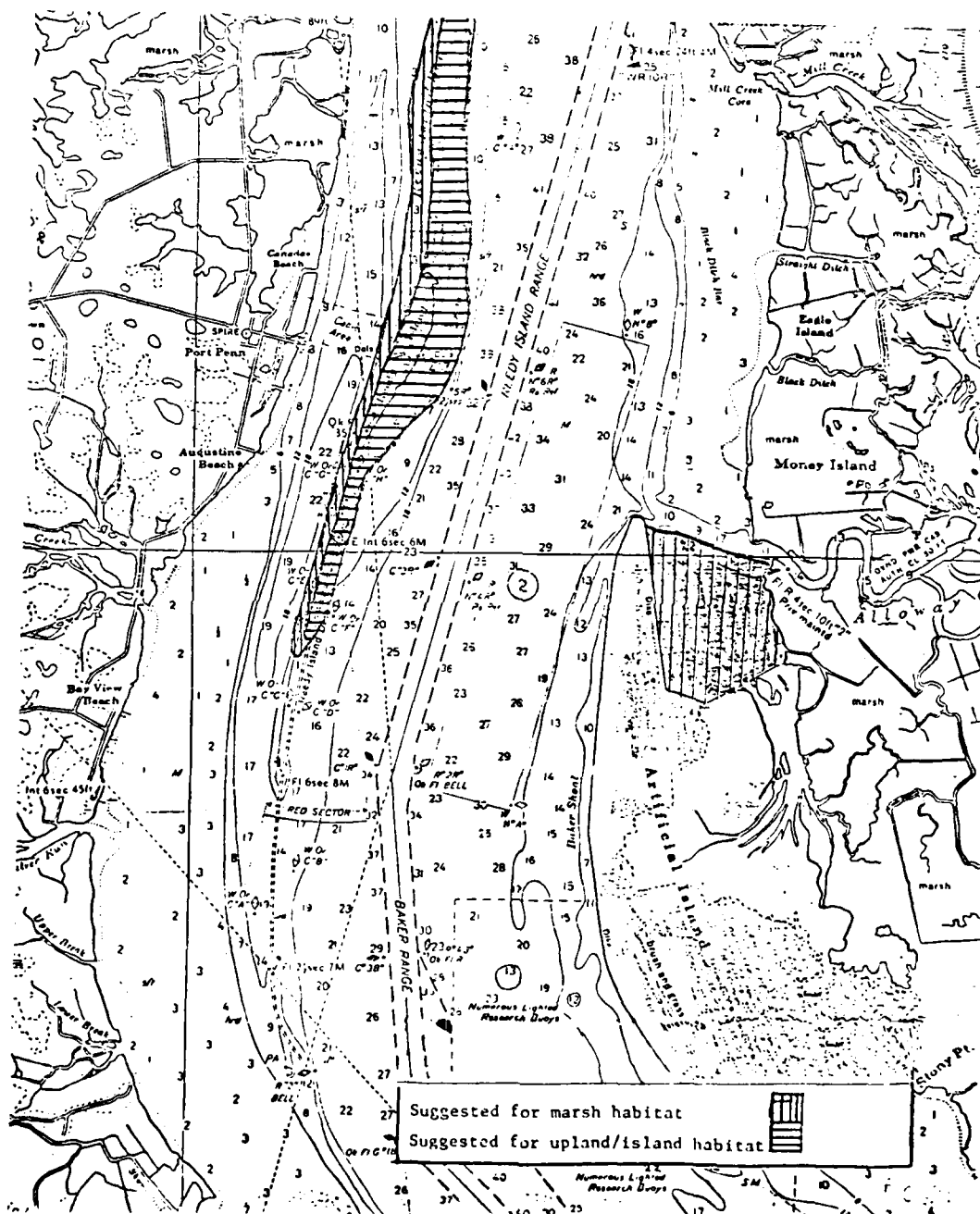


Figure 50. Artificial Island and Reedy Island sites showing potential for marsh and/or upland/island development

Reedy Island

333. This small river island appears to have had dredged material deposits placed there in the past although it is probably a natural island. It has eroded and much of the former island is now mud flat. The shallow areas shown in Figure 50 can be used for dredged material placement to create both upland habitat on the channel side and marsh habitat on the lee side of the island.

Salem Cove

334. Salem Cove (Figure 51) is an area that has been used for dredged material disposal in past years. The deposits have eroded to shallow or submerged river bottom. The cove has approximately 8 km² of shallow water that could conceivably be used for marsh development and/or upland development if a disposal site was necessary at that location. However, the cove probably should be a low-priority site since, at the present and in the foreseeable future, other CE disposal sites are available in the vicinity and are planned for use. It appears possible to create a marsh at this location; however, a large amount of shallow river bottom would be covered. Salem Cove is sufficiently distant from the contaminated areas with low dissolved oxygen levels that there probably is increased benthos in the area. Thorough investigations of impacts on benthos should be made at that site before it is used as a disposal site.

Pea Patch Island

335. Pea Patch Island (Figure 52) is the location of historic Fort Delaware, a tourist attraction, as well as the home of a yearly average of 14,000 herons, ibises, and egrets. This colony usually contains nine different species and is the only colony within the Delaware River Valley (Wiese 1977). Pea Patch has had deposits of dredged material in past years, but none recently. The heronry is located on a disposal site. The island has eroded but has a large expanse of common reed marsh on its lee side. The waterbirds have killed much of the tree and shrub vegetation through continuous use and defecation. This is a natural occurrence; however, since the island is small and has little upland area for expansion, the colony is being crowded out into the

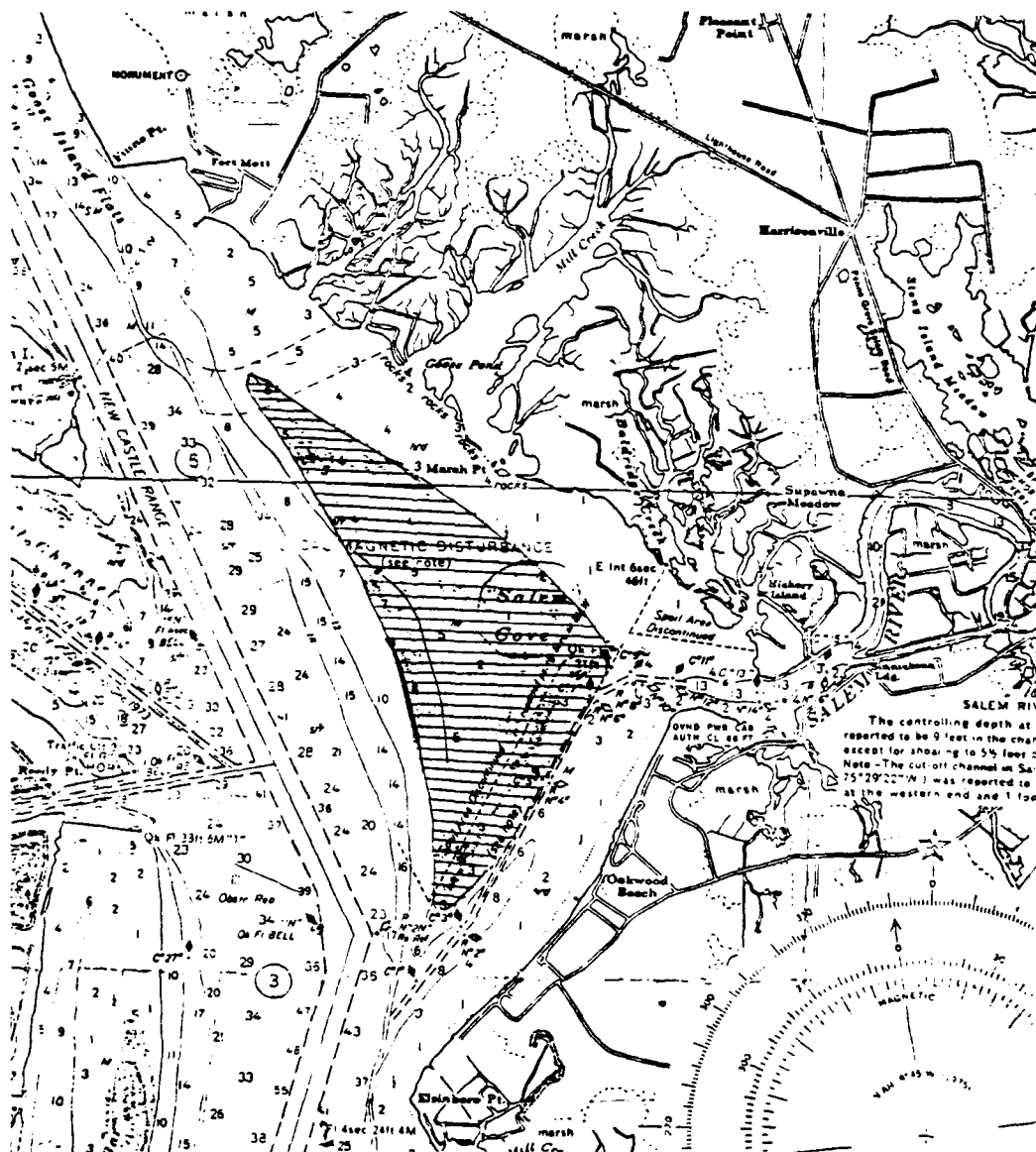


Figure 51. Salem Cove site portrayed entirely as a potential up-land disposal site. It presently is open water

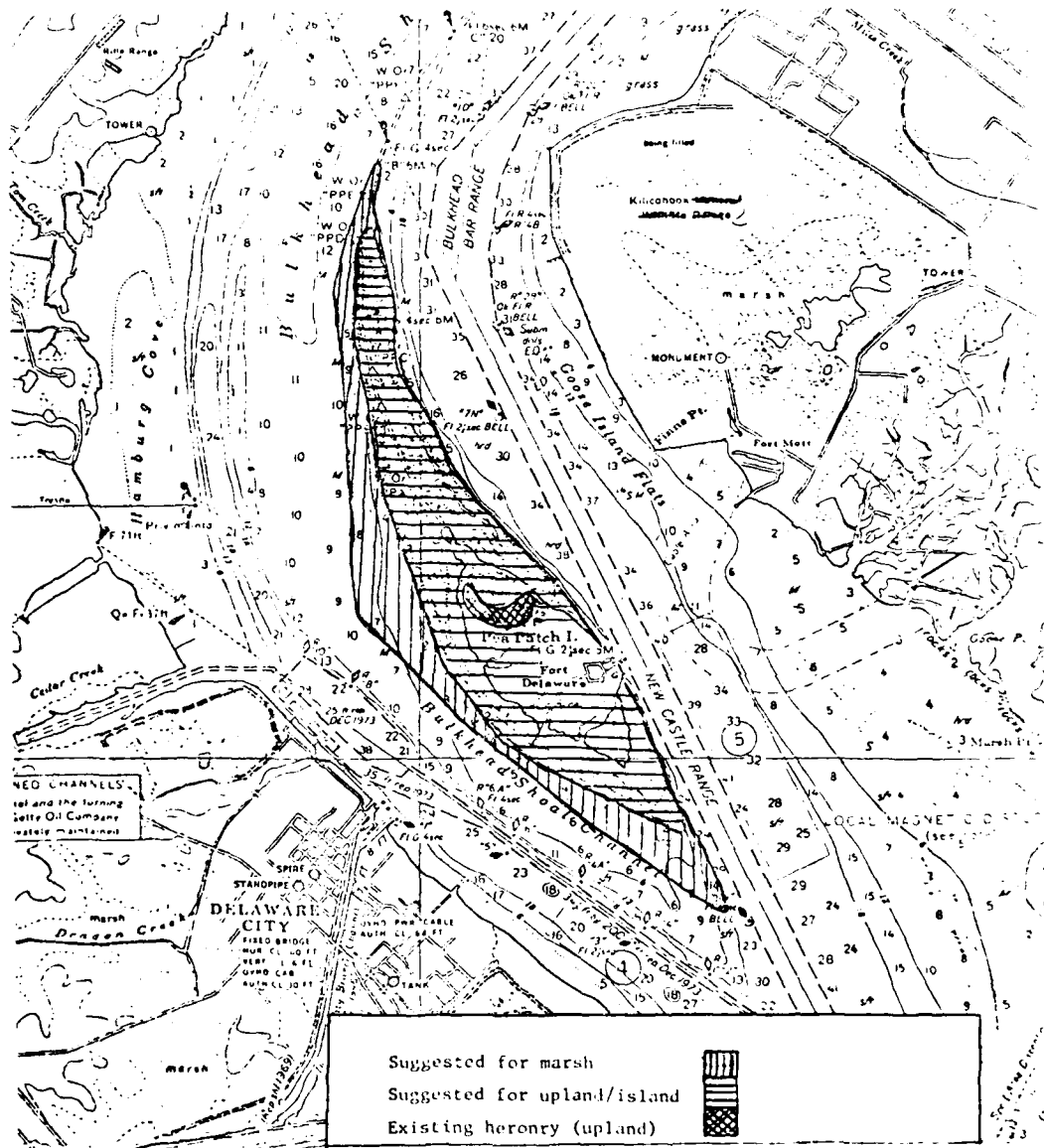


Figure 52. Pea Patch Island site showing potential marsh and upland/land development using dredged material

common reed marsh to find nesting sites, an unnatural habitat for tree-nesting species.

336. The placement of dredged material adjacent to old deposits as shown in Figure 52 to create additional upland habitat, with more material placed on the lee side of upland deposits to create additional marsh, should enhance the wildlife use and productivity of Pea Patch Island. This island is recommended as a high-priority site and probably should be developed as both marsh and upland habitat in combination to provide both feeding and nesting habitat for the heronry. The National Audubon Society (NAS) research office could be contacted for assistance with this colony. The best persons to contact would be Mr. Frank Dunstan, Mid-Atlantic Regional Director, NAS, P. O. Box 4181, Harrisburg, PA 17111; Mr. Johan Wiese, Tall Timbers Research Station, Rt. 1, Box 160, Tallahassee, FL 32303; and Dr. John Ogden, NAS, 115 Indian Mound Trail, Tavernier, FL 33070.

Helms Cove

337. Helms Cove (Figure 53) is a natural cove that has a residential area to its north and an industrial site to the south. It is presently a mud flat that could be raised to an intertidal elevation with a dredged material deposit and planted with marsh plant species or allowed to colonize naturally. It appears to be a very favorable site for a small marsh.

Chester/Monds Island

338. These islands (Figure 54) have mud flats and shallow river bottom adjacent to them, and marsh presently exists on Monds Island and the nearby riverbank area. The islands are isolated from much human activity except for dredged material disposal operations on the riverbank and shipping traffic. The islands themselves could offer protection for a marsh built on the mud flats south and west of Monds and east of Chester. This site seems quite favorable for marsh development. The site could also be used for upland habitat development in conjunction with or in lieu of marsh development. Chester Island elevation could be raised using dredged material and the training dike area could be filled and both made into a larger upland area, while Monds Island

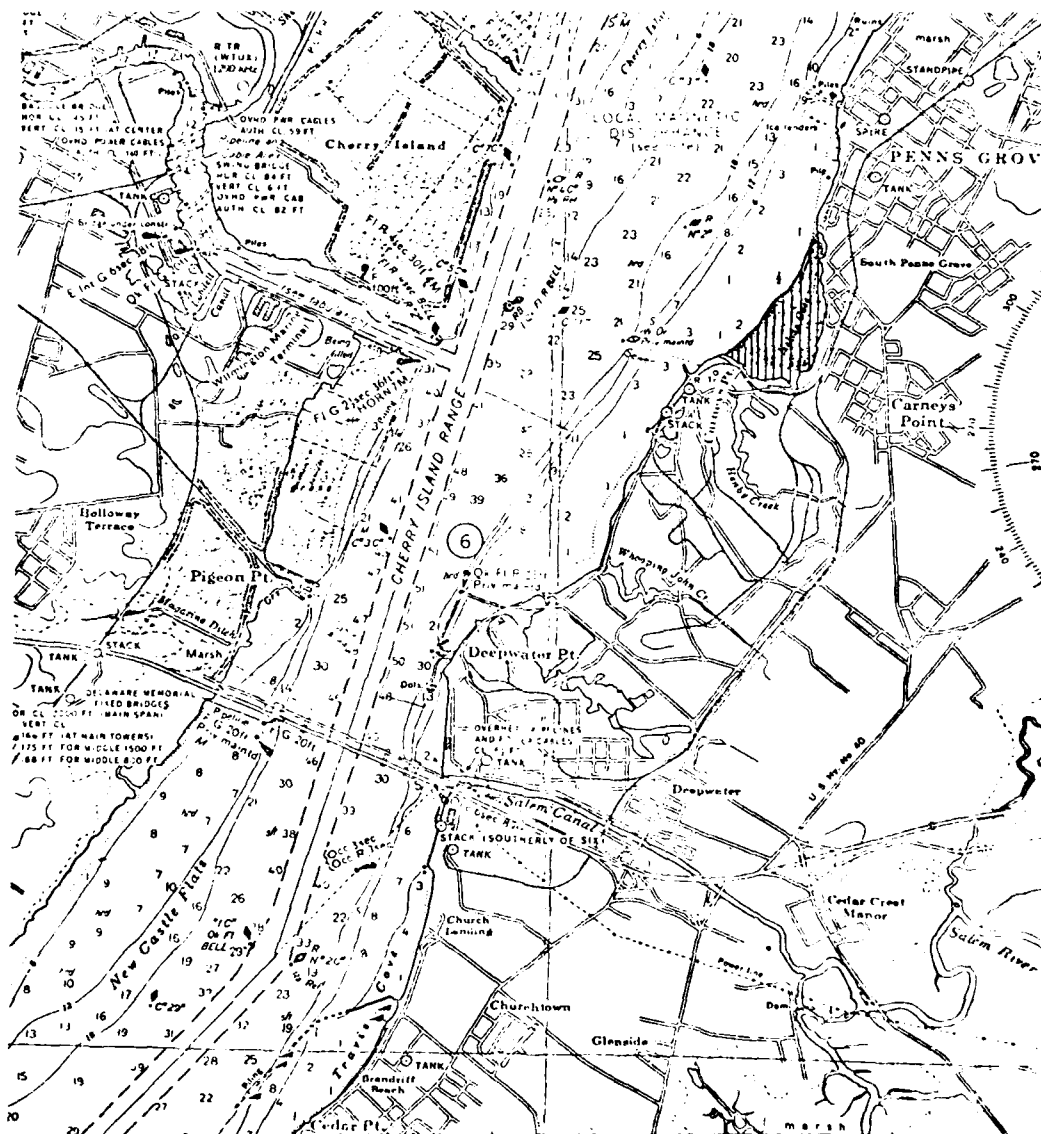


Figure 53. Helms Cove site portrayed as a small marsh development site

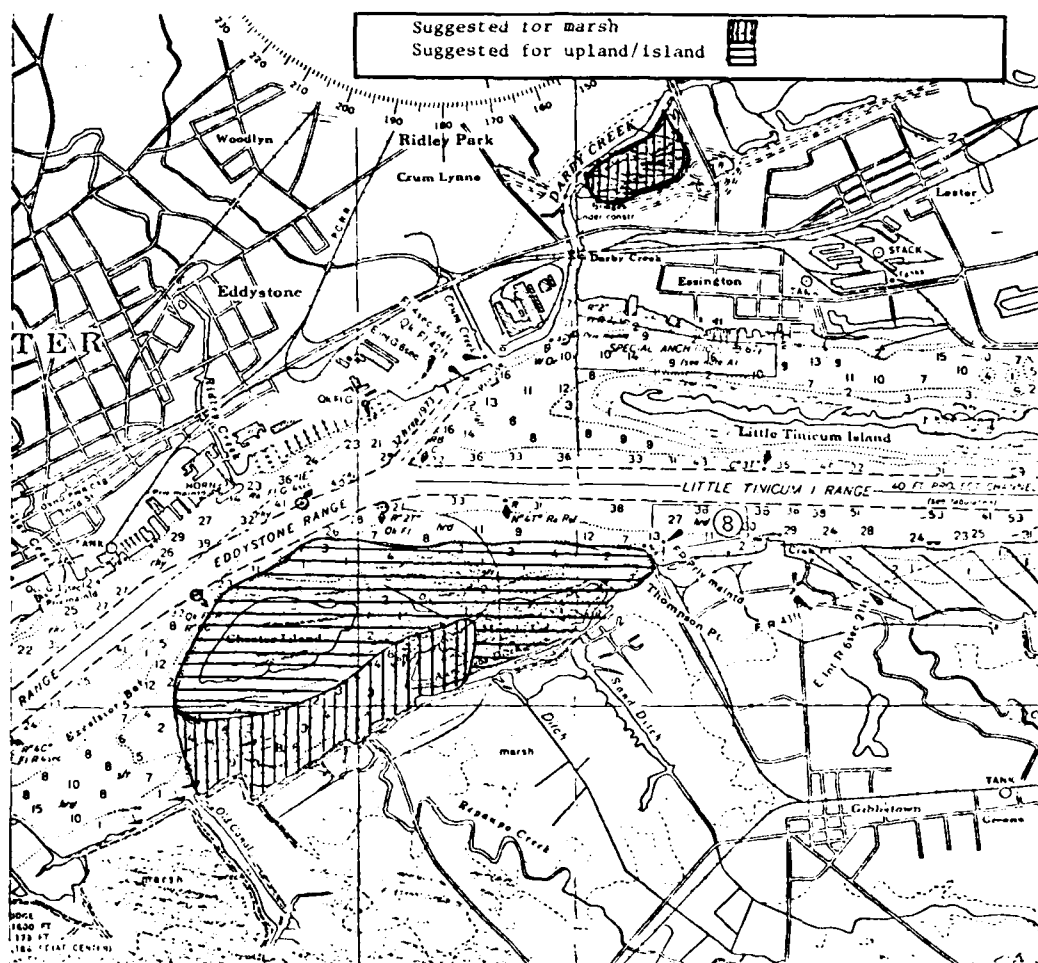


Figure 54. Darby Creek and Chester/Monds Islands sites. Darby Creek is portrayed as marsh but could be shallow aquatic habitat as well or a combination of marsh/aquatic habitat. Chester/Monds Islands are portrayed as a total large site developed as both upland and marsh. The erection of a dike on the northern (upstream) edge of the site may allow the area to be built at less expense. Effluent could filter back through existing vegetation before it enters the river again at the south (downstream) end of the disposal area. A gentle slope capable of supporting an intertidal marsh should result from these techniques

and the created cove area could be raised to upland or could remain at an intertidal level to create a marsh.

339. If only an upland site is built, the entire area of Chester and Monds Islands and the mud flats and training dike could be included. In this case, it is not likely that an upland wildlife habitat would remain unless so designated, as it would then also be suitable for industrial development.

Darby Creek/Tinicum
Wildlife Preserve

340. When Interstate 95 was constructed through Tinicum Preserve, borrow material taken from an area by Darby Creek created a hole approximately 60 feet deep and 78 acres in size (Figure 54). It is presently a pond area and has wildlife use. However, the Tinicum authorities have considered the possibility of filling the hole to create more marsh within the wildlife preserve. A marsh could be built by filling the hole to an intertidal elevation. A more productive pond may be achieved by filling the hole only to within 6-10 feet of the water surface with a gentle slope and uneven bottom topography. Both kinds of habitat (marsh and shallow aquatic) could be achieved by careful placement of dredged material and an interspersing of the habitat types would probably best meet Tinicum Preserve wildlife requirements.

341. Darby Creek is an excellent candidate for marsh and/or aquatic habitat development. It is isolated and protected and Tinicum Preserve authorities are favorable to the use of dredged material for this purpose.

Crosswicks Creek

342. There appear to be no suitable locations for marsh development from RM 86 to RM 128 because of dense urban and industrial development adjacent to the Delaware River in both New Jersey and Pennsylvania. Crosswicks Creek (RM 128) lies between Trenton and Philadelphia and its delta forms a large mud flat at the southern tip of Duck Island (Figure 55). The marsh area at Crosswicks Creek is presently used by overwintering and migratory waterfowl and a marsh at the mouth of the creek would benefit these birds. However, before

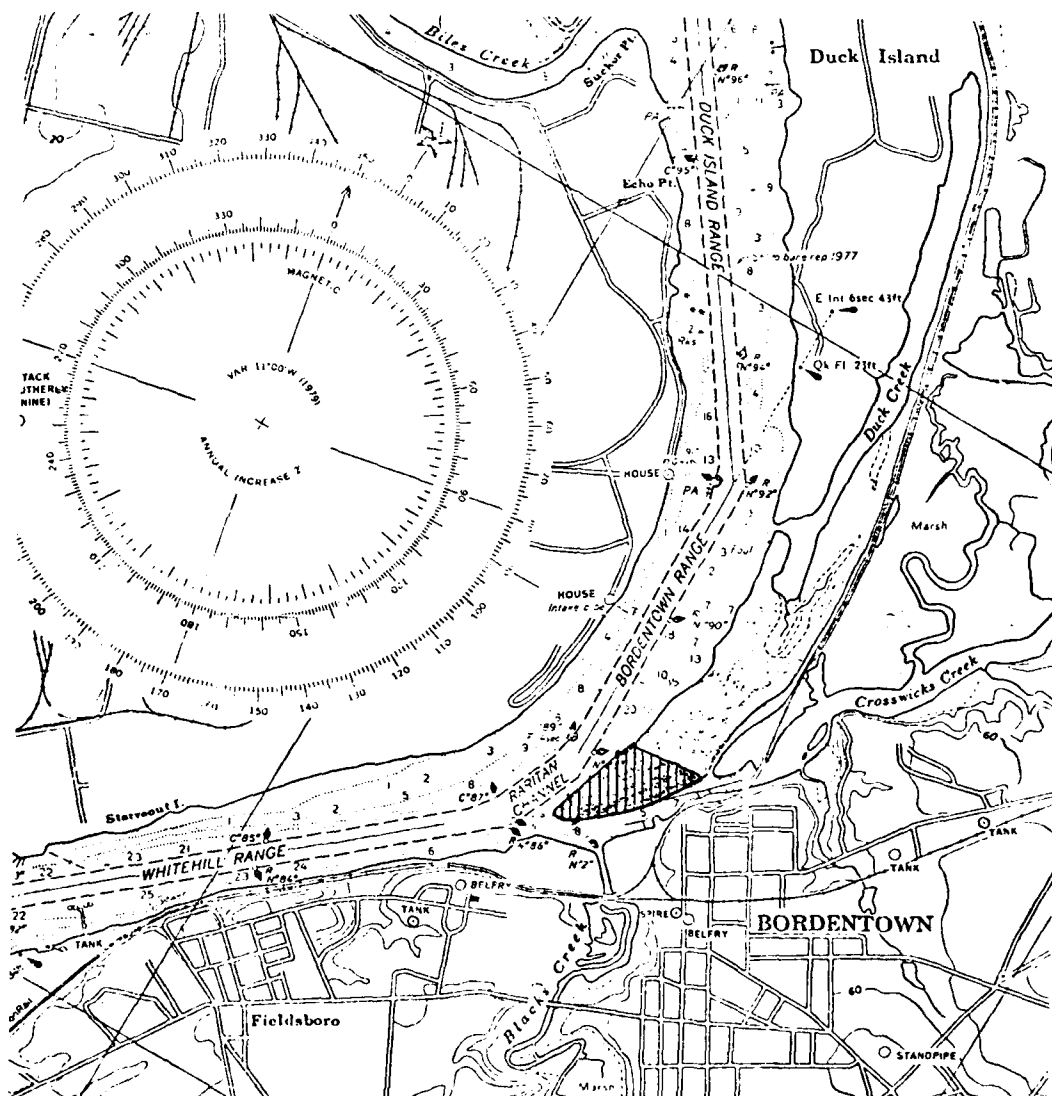


Figure 55. Crosswicks Creek site portrayed as a small marsh development site. This area is tentatively scheduled for a future limited access highway right-of-way

decisions concerning this site are made, surveys of aquatic and benthic organisms and plants should be made to determine present extent of wildlife use and environmental quality. The site could already be more productive than initially indicated and may need no changes.

Problems Likely to be Encountered

343. Sites discussed in this report are assessed only in terms of their biological suitability. No attempt was made at determining ownership, costs, or engineering feasibility, which is called for in the contract Scope of Work with Mitre Corporation.

344. Any habitat development in the Delaware River must take into consideration the quality of the dredged material being used for this purpose. Heavy metals occur in the Delaware River and will occur in dredged material deposits at varying levels. Before any plans for specific habitat development sites are made, intensive sampling to determine pollutant content of dredged material for that site should be made. Moderately polluted material may be placed at an intertidal level as most metals are not taken up in great quantities under anaerobic conditions (Lee et al. 1978). Materials of this nature should not be used for upland development because some metals may be taken up readily in aerobic soils.

345. Benthic samples should be made at specific sites to determine actual presence and quantity of organisms. If benthic communities are diverse and healthy, the sites should probably not be used for habitat development, as they are productive as mud flats. Environmental monitoring should probably occur on any site selected for habitat development using dredged material. This can be costly but it will not only provide useful data for the site, but satisfy some requirements for environmental control by other agencies. It is cautioned that each suggested site should be examined individually, carefully, and objectively before final site selection is made or habitat development construction activities occur. Biologically productive sites probably should be removed from consideration for further development. Sites

showing little sign of productive benthic, wildlife, or marsh activities could be considered likely candidates for development.

346. Unless common reed, a very persistent and hearty marsh species occurring on disturbed sites, is the desired vegetation for a marsh development site, marsh building probably should not be undertaken. Common reed is abundant in the Delaware River estuary as a source of propagules and will most likely out-compete any other marsh vegetation. Other marsh species can be introduced to a new site and efforts made to control common reed, but it is hard to predict success of such an effort unless there is an increase in salinity which kills common reed (Neiring and Warren 1980). It should also be noted that common reed control has been practiced in some coastal areas with varying success and other marsh species have colonized in its place. In defense of this species, it should be noted that while it is not especially desirable for many species of coastal wildlife, it provides a great degree of stabilization and, when not confined by a dike, contributes detritus to the estuary system (Geller 1972; Hunt et al. 1978). Undiked common reed marshes are in general productive habitats in the estuary system.

Recommendations for Scope of Work

347. In addition to those listed in the Scope of Work for Mitre Corporation's contract, at least three other items should be included in the scope as well: biological feasibility, substrate characteristics, and sociopolitical considerations. These items are essential to the determination of ultimate site use and should be involved from the initial planning stage.

348. Since the scope called for only five sites to be ranked with sufficient priority to be considered for development, that number, or at least the list of potential sites, should be changed. Potential sites listed in the scope do not correspond with the sites listed in paragraph 330. The list to be examined by Mitre Corporation should be expanded to include the suggested sites in this report as well as the seven listed in the scope.

349. The list of references including Environmental Laboratory (1978a) to be consulted, as shown in the scope, should be expanded to include WES Synthesis Reports TR DS-78-17 (Hunt et al. 1978) and TR DS-78-18 (Soots and Landin 1978), which involve habitat development using dredged material in upland, island, and some marsh situations. Additional WES references are available for consultation as well and a list of WES reports is attached for use by the PD and Mitre Corporation. Authors of the various WES reports on the scope list of references are also available for consultation to the PD and/or Mitre Corporation at PD request.

Summary and Priority

350. The eight sites listed in paragraph 330 can be tentatively prioritized from most potential to least potential as follows, based on data made available to WES: Darby Creek; Pea Patch Island; Chester/Monds Islands; Crosswicks Creek; Aritificial Island; Helms Cove; Reedy Island; and Salem Cove. Again, these priorities are based primarily on biological considerations, with some background political and engineering data influencing certain priorities. Darby Creek and Pea Patch Island should be most beneficial over a long period of time and also seem the most likely to be considered acceptable to other agencies and officials.

PART VIII: SHORELINE STABILIZATION AND MARSH DEVELOPMENT WEST OF
TANGIER ISLAND, CHESAPEAKE BAY, VIRGINIA

by

M. C. Landin and M. K. Vincent

Preliminary Feasibility Evaluation

351. Preliminary evaluation (including site reconnaissance) of the possibility of a project combining shoreline stabilization, dredged material disposal, and marsh development on the west side of Tangier Island indicates that it is technically feasible and does warrant further consideration.

352. The major problem in conducting the project would be expense. First, the water energy conditions at the disposal site require that a substantial shoreline protection structure be installed. Second, the approximately 7- to 10-mile distance between the dredging and disposal sites would involve substantial costs for transport by hopper dredge and for pumping the material about 1.5 to 2 miles by pipeline. Finally, there may be a problem in economically locating and obtaining sand and rock materials for constructing the protection structure.

Engineering aspects

353. To meet the severe erosion problem on Tangier Island, a substantial protection structure is needed. Further, if the project is to involve marsh development, a containment structure would be required to retain the fine-grained dredged material from Rappahannock Shoals and to protect the marsh. For the proposed project, the structure should be similar to the seawall described in the Task Force report.* The other stabilization techniques considered by the Task Force lack permanence, and over the long term, because of maintenance costs, would probably be as costly or more costly than the more effective seawall.

* "Shore Erosion at Tangier Island" with Dr. Robert J. Byrne as Task Leader, Virginia Institute of Marine Science, February 1976.

354. Based on the data supplied, there is nothing to indicate that, from an engineering standpoint, the seawall and marsh development project could not be undertaken. However, a complete evaluation cannot be made without more detailed information on bottom topography west of Tangier Island, an estimate of the volume of material to be dredged, and an estimate of what volume that material will occupy when disposed. For determining containment area sizing, samples of the material to be dredged need to be analyzed in the laboratory. The various tests for engineering characteristics, discussed by Palermo et al. (1978), should include laboratory classification under the Unified Soil Classification System, grain-size analysis, and Atterberg limit determinations. These tests will also provide the information on consolidation characteristics that is needed to predict the final stable elevation. From this information, a design for the proper location of the seawall can be developed. Depending on the location, the design of the seaward apron may need revision to effectively prevent toe scour.

355. Without information on foundation conditions within the proposed disposal area and along the center line of the proposed seawall, this evaluation can only be preliminary. Foundation information is necessary to predict foundation response to the load of the seawall and the dredged material. Since the load will be substantial, the foundation characteristics are the key to determining the technical feasibility of the project.

356. Since the project is located in a high-energy area, it is important that the seawall be high enough to prevent overtopping by storm waves. Preliminary study indicates that a containment structure like that described in the Task Force report would need to be at least 3.3 yds high. The actual height would depend on the water depth, tidal range, and wave action at the seawall line.

Marsh development aspects

357. For marsh establishment, the optimal final surface elevation of the dredged material should range from mhw to -0.4 yds (mhw). Consideration needs to be given to providing adequate tidal circulation for the marsh and for the export of the annual standing crop of marsh

vegetation. Designs for this can be developed once the seawall location and width of the disposal area are determined.

358. Data available at this time on the heavy metals concentrations in sediments at Rappahannock Shoals do not indicate any problem in developing marsh with this material, either for plant growth or heavy metal uptake. For more precise analysis, a procedure is available (Lee et al. 1978) that has good potential to predict uptake of zinc, copper, and cadmium by marsh plants. Through another technique, recently tested at WES, it is possible to field test for uptake; this involves a comparative analysis of tissue of plants grown in the dredged material and in a natural marsh substrate.

359. Marsh species which naturally occur on Tangier Island and that would be likely candidates for establishment in a planted marsh are:

- a. Smooth cordgrass. This species should be planted directly behind any containment structure where tidal inundation, wave action, and salinities are greatest. This is the only east coast saltmarsh species that can tolerate such conditions.
- b. Saltmeadow cordgrass and saltgrass could be planted in mixed stands at a slightly higher elevation behind the smooth cordgrass where wave action is less and tidal inundation periods are shorter. On Tangier Island these two species occur over the entire upland area, especially saltgrass, therefore propagule sources are probably adequate.

A wide band of smooth cordgrass or a planting entirely of smooth cordgrass may be desirable as saltmeadow cordgrass and saltgrass would occur by natural invasion as the newly planted marsh matured. Only transplants (or sprigs) should be used as propagules. Seeds are not feasible in this situation. Reference to the Environmental Laboratory (1978a) report on marsh development would be of benefit for details.

Project impacts

360. As pointed out by the Task Force on shore erosion at Tangier Island, the seawall would have an effect on the portion of the island north of the Tangier Channel, on the Tangier Channel, and on the spit south of the project. The extent of the impact would probably depend on how wide the project area is. The presence of the seawall may

affect current strength, particularly during storms; the resultant impact on erosion and sedimentation in the area should be determined during project planning. It may then be necessary to revise some aspects of the project design.

Costs

361. A seawall constructed of rock, quarried and barged to the site, will be very expensive, and may negate the feasibility of the project. Costs based on quarry-run rock dikes per linear yard at a 3.0-yd height are \$1,200 (Eckert et al. 1978). The 3.3-yd seawall recommended by the Task Force has an estimated cost per linear yard of \$1,750. Since the proposed area to be protected is 2,524 linear yards, costs for the seawall can be expected to be substantial.

362. Marsh establishment costs will be minor compared to seawall and dredged material placement expenses. As a rule of thumb, 40-80 manhours per acre are adequate for digging, preparing, and planting transplants on a site. If the seawall is found to be best located at 30 yd from the existing shore, for example, where water depths are approximately 1.5 to 2.0 yd, then a marsh establishment area will exist of 19 acres. Marsh establishment labor costs thus would be in the range of 760 to 1,520 manhours total for that phase of the project. Unforeseen difficulties in obtaining plant material, finding labor, or planting the site would increase cost.

Recommendations

363. There is, at present, no obvious technical reason why the shoreline stability and marsh development project could not be accomplished. If designed and conducted properly the project would effectively solve the serious erosion problem on Tangier Island. Before proceeding, however, it is extremely important to determine the foundation conditions of the site. This information is critical in providing a complete feasibility evaluation and in properly designing the seawall.

The impact of the presence of the seawall on current conditions during storms should also be investigated.

364. Samples of the material to be dredged need to be taken and analyzed in the laboratory for physical characteristics needed for determining containment area sizing and final elevation. This is necessary for any marsh establishment work to be successful. It is further recommended that a pilot study, involving growing the selected plant species in containers filled with dredged material from Rappahannock Shoals, be undertaken to determine projected success of the marsh.

365. A project impact evaluation cannot be made without a preliminary project design; from this a final design to mitigate any negative impacts can be developed. A topographic survey will be necessary to set location and height of a containment/protection structure and to make a preliminary project design. Once technical aspects of the project's design have been developed, the economic feasibility can be assessed.

PART IX: PRELIMINARY FEASIBILITY EVALUATION OF DREDGED MATERIAL
DISPOSAL, HABITAT DEVELOPMENT, AND EROSION CONTROL
AT SMITH ISLAND, CHESAPEAKE BAY, MARYLAND

by

M. C. Landin, T. R. Patin, and L. J. Hunt

Introduction

366. Based on a preliminary review by DOTS, several locations at Smith Island appear as if they would benefit from erosion control through habitat development with dredged material. Recommendations for marsh development and some discussion of the potential for island and upland habitat are presented. Additional physical data will be required before specific feasibility can be determined and additional recommendations given.

Marsh Development

367. Data in hand show three sites suitable for erosion control through marsh development (Figure 56):

- a. Between Swan Island and Channel Point.
- b. In the open water and existing marsh between Rhodes Point and Hog Neck Island.
- c. Along the Chesapeake Bay shoreline due east of Rhodes Point.

Additionally, a number of sites are suitable for marsh development as a means of dredged material disposal (Figure 57) and as benefits for erosion control desired on the east portion of Smith Island. Situations and dimensions in both figures are for illustration only and are not intended as design recommendations.

Engineering and operational aspects

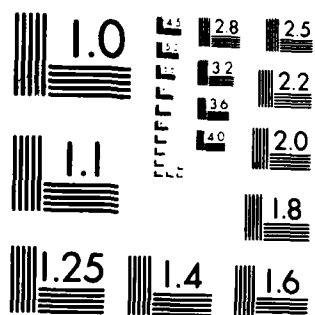
368. Eckert et al. (1978), Environmental Laboratory (1978a), and Palermo and Zeigler (1976, 1977) present detailed design concepts and general marsh construction guidelines.

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369. Marsh could be developed at Site A (Figure 56) by construction of a sandbag or sand dike between Swan Island and Channel Point and disposal of dredged material behind the dike to the east. Sand for dike construction should be available from either the existing disposal site on Swan Island or from channel maintenance dredging between jetties.

370. Site B encompasses an area of open water and existing wetlands, with several specific locations where sediments might be placed and marsh established. Unconfined disposal could be used to broaden the existing marsh and/or to raise it to higher marsh.

371. Dredged material disposal at Site C would require protection from the energies of wind and water coming from the bay and would result in a relatively permanent form of shoreline protection. Requirements for a retention structure would be similar to those at Tangier Island, although the height needed is lower.

372. Material for marsh development may come either from the Rappahannock Shoals or from maintenance dredging on Smith Island. Transport of local sediments would be less costly than the Rappahannock material. Local sediments that are sand may also be used in construction.

373. Design of the retention structure required at Site C would be based on such factors as the desired final elevation of the marsh, volume of material to be placed, maximum fill and ponding levels, free-board requirements, bottom topography, foundation conditions, erosive energies, and construction methods and materials. Environmental Laboratory (1978a) discusses these aspects of marsh development. Design and construction must take into account potential erosion and scour. The less obtrusive a structure, the less it will affect existing conditions.

374. Adequate tidal circulation is important for successful establishment of a marsh and should develop on its own if the tide is allowed to enter the site. This can be accomplished by leaving an opening in a confinement at a protected location by use of a temporary sandbag dike for confinement during the dredging process or by use of a board wier on the protected side of a dike.

375. Final surface elevation of dredged material placed for low marsh development should be between mean high water (mhw) and 0.4 yd below

mhw; high marsh will require placement between mhw and 0.4 yd above mhw. Attaining a suitable final elevation on sediments that require retention is dependent on the amount of dredged material to be placed; the average thickness of layer placed; surface area, configuration, and volume of the site; and consolidation of the dredged material and/or of compressible foundation soils (Environmental Laboratory 1978a). These design criteria can be derived from field and laboratory tests described in Palermo et al. (1978).

Vegetation aspects

376. Salt marsh species that could be planted on dredged material on Smith Island are:

- a. Smooth cordgrass. This species could be planted behind a permanent or temporary protection structure or on unconfined sediments, depending on energy conditions. This species is characteristic of the lowest marsh elevations and is the most tolerant east coast species to combined periods of extended inundation and high salinity.
- b. Saltmeadow cordgrass. This species could be planted in a mixture with smooth cordgrass at a slightly higher elevation behind the smooth cordgrass, where wave action is less and tidal inundation periods are shorter. This species may not be feasible at any site other than Site C as it is not tolerant of excessive overwash and shifting of substrate.

377. Both species are conducive to substrate stabilization and are found on the island in natural stands which could be used as sources for propagules. An entire planting of smooth cordgrass may be desirable at any site, as saltmeadow cordgrass will most likely invade as the marsh matures. Only transplants or sprigs should be used as propagules on these sites. Refer to Environmental Laboratory (1978a) for additional details and for guidelines on planting. Rapid vegetative cover would be desirable at Smith Island, so conservative specifications on species selection, propagule type, plant spacing, fertilizer application, etc., apply. For example, it would be desirable to plant at intervals of less than 1.0 yd.

378. Present data on metal concentrations in sediments of the Rappahannock Shoals do not suggest any problems affecting either plant growth or metal uptake. For additional analysis, a laboratory

procedure is available (Lee et al. 1978) that has potential to predict uptake of zinc, copper, and cadmium by marsh plants. Wolf et al. (1978) describe a preliminary field test to verify plant growth on sediments to be used for marsh development.

Island Development

379. Small, stable islands could be built at several locations on Smith Island; with correct placement, especially at Site B, they would contribute to erosion control. Either Rappahannock Shoal or local maintenance material could be used with the degree of confinement determined by specific location and grain size of the sediments. Final elevation of an island should be high enough to remove it from the direct influence of tidal flooding but low enough to avoid drought conditions for plants.

380. For rapid stabilization, vegetation propagation is advisable. Selection of plant species to use would be determined by their ability to establish themselves and stabilize soil and by other uses of the island (wildlife or recreation). Smooth cordgrass plantings around the perimeter of an island in a backwater area would aid in stabilization and erosion control. More extreme energy conditions might require rip-rap or other forms of protection.

381. Soots and Landin (1978) discuss biological and physical aspects of island development. Engineering information may be obtained from Environmental Laboratory (1978a), Hunt et al. (1978), and Mr. James Wells of the U. S. Army Engineer District, Wilmington; that District has constructed islands for bird nesting areas and dredged material disposal.

Upland Development

382. Land above high tide establishment at either Site A or anywhere along the east or west shore of Hog Island would help control erosion. Procedures for upland habitat development are found in Hunt et al. (1978).

383. Three concerns with this alternative are:

- a. The degree and type of protection or retention required for disposal and subsequent stabilization.
- b. Protection of existing wetlands from impacts during disposal and after construction.
- c. Displacement of other habitat types.

Potential Impacts

384. Habitat displacement is an impact common to all alternatives: displacement of low marsh by high marsh or water bottom by marsh or upland. Decisions on the severity and importance of this impact must be made for each situation and through coordination with all agencies involved. See Lunz et al. (1978a) for further discussion.

385. Sediment transport would be affected by placement of any structure that changes hydraulic patterns. Impacts include erosion and scour of the water bottom and changes in sediment deposition, such as decreased nourishment of existing marshes or sedimentation of channels. A habitat or structure should be designed to minimize any such adverse impacts.

386. The Martin National Wildlife Refuge must be protected from disturbance of its wildlife and habitat by disposal and construction operations.

Costs

387. Costs of project design, testing, dredging, disposal, etc., are best calculated by the Baltimore District. Approximate 1977 costs of protection and retention structures are found in Eckert et al. (1978). Costs of a 3.0-yd sea wall constructed of rock quarried and barged to the site, such as might be required at Site C, would be \$1,200/lin yd. A 3.0-yd sand sike hydraulically placed would be \$120/lin yd. The same height sandbag dike would be \$825/lin yd. If filter cloth were necessary under the bags, there would be an additional cost of about \$3.15/sq yd.

388. Marsh propagation costs will be determined by the labor and expense of obtaining, transporting, handling, storing, and planting propagules; the number of propagules required; any soil treatments necessary such as fertilization; and maintenance efforts. Using marshes on Smith Island as sources of transplants, 40-80 manhours/acre is adequate for digging, preparing, and planting transplants on 1.0-yd intervals. Efforts will increase with smaller intervals.

Recommendations

389. Since existing information shows dredged material disposal and subsequent habitat development for erosion control to be feasible at Smith Island, it is recommended that planning continue and additional data be compiled or collected. Further information is needed on:

- a. Hydraulic characteristics of potential sites including water elevation, wave and wind energies, and currents and sediment transport patterns.
- b. Distribution and volumes of soil types in maintenance dredged material.
- c. Foundation conditions at the location of any potential protection or retention structure.
- d. Bottom topography of potential sites.
- e. Sedimentation and consolidation behavior of any fine-grained material to be used.
- f. Elevation of existing marshes near the potential site.
- g. Soil salinities of any material to be placed upland and water salinities in areas of potential marsh.

390. Potential impacts should be considered:

- a. Changes in sediment transport that might cause a channel to fill in, a marsh to be smothered or deprived of adequate tidal nourishment, or erosion to occur.
- b. Any actions that might damage wetlands, commercial fisheries, or the wildlife refuge.

391. A pilot study to verify plant growth in sediments to be used for marsh establishment is recommended.

392. Wetland, island, and/or upland habitat should be considered for:

- a. Erosion control on the west side of Smith Island.
- b. Routine maintenance dredging disposal in more sheltered portions of the island.

393. The planning and design of the Smith Island work should be documented as an aid in recording advice, procedures, and problems for projects of this nature. Since each project must be evaluated in detail on its own merits, a larger number of case studies than now exist are needed to ensure more successes in habitat development.

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APPENDIX A: LIST OF COMMON AND SCIENTIFIC NAMES
OF FLORA AND FAUNA MENTIONED IN THE TEXT

<u>Common Name</u>	<u>Scientific Name</u>
	<u>Flora</u>
American elm	<u>Ulmus americana</u>
American holly	<u>Ilex opaca</u>
Annual pickleweed	<u>Salicornia bigelovii</u>
Arrow arum	<u>Peltandra virginica</u>
Arrowheads	<u>Sagittaria</u> spp.
Bald cypress	<u>Taxodium distichum</u>
Big cordgrass	<u>Spartina cynosuroides</u>
Bitternut hickory	<u>Carya cordiformis</u>
Black cherry	<u>Prunus serotina</u>
Black willow	<u>Salix nigra</u>
Blueberry	<u>Vaccinium elliotii</u>
Buttonbush	<u>Cephalanthus occidentalis</u>
Cane	<u>Arundinaria gigantea</u>
Cattail	<u>Typha</u> spp.
Cedar elm	<u>Ulmus crassifolia</u>
Cherrybark oak	<u>Quercus falcata</u>
Chinese tallow	<u>Sapium sebiferum</u>
Chufa	<u>Cyperus esculentus</u>
Common Bermuda grass	<u>Cynodon dactylon</u>
Common reed	<u>Phragmites australis</u>
Common threesquare	<u>Scirpus americanus</u>
Coontail	<u>Ceratophyllum demersum</u>
Cow oak	<u>Quercus michauxii</u>
Deciduous holly	<u>Ilex dicidua</u>
Dog fennel	<u>Eupatorium capillofolium</u>
Duck potato	<u>Sagittaria latifolia</u>
Duckweed	<u>Lemna</u> spp.

<u>Common Name</u>	<u>Scientific Name</u>
Dwarf palmetto	<u>Sabal minor</u>
Eastern cottonwood	<u>Populus deltoides</u>
Fanwort	<u>Cabomba caroliniana</u>
Flowering dogwood	<u>Cornus florida</u>
Frankenia	<u>Frankenia grandifolia</u>
French mulberry	<u>Callicarpa americana</u>
Frog fruit	<u>Lippia spp.</u>
Green ash	<u>Fraxinus pennsylvanica</u>
Greenhaw	<u>Crataegus viridis</u>
Groundsel tree	<u>Baccharis halimifolia</u>
Gulf cordgrass	<u>Spartina spartinae</u>
Hawthorn	<u>Crataegus spathulata</u>
Horsesugar	<u>Symplocos tinctoria</u>
Ironweed	<u>Veronia altissima</u>
Ironwood	<u>Carpinus caroliniana</u>
Live oak	<u>Quercus virginiana</u>
Lizard tail	<u>Saururus cernuus</u>
Loblolly pine	<u>Pinus taeda</u>
Marsh elder	<u>Iva frutescens</u>
Mockernut hickory	<u>Carya tomentosa</u>
Mock orange	<u>Styrax americana</u>
Mule fat	<u>Baccharis emoryii</u>
Nettles	<u>Urtica spp.</u>
Nodding smartweed	<u>Polygonum lapathifolium</u>
Nutsedges	<u>Cyperus spp.</u>
Nuttall oak	<u>Quercus nuttallii</u>
Overcup oak	<u>Quercus lyrata</u>
Pacific cordgrass	<u>Spartina foliosa</u>
Peach-leaved willow	<u>Salix amygdaloides</u>
Pecan	<u>Carya illinoensis</u>
Perennial ryegrass	<u>Lolium perenne</u>
Pickleweed	<u>Salicornia virginica</u>
Planer elm	<u>Planera aquatica</u>

<u>Common Name</u>	<u>Scientific Name</u>
Post oak	<u>Quercus stellata</u>
Ragweed	<u>Ambrosia</u> spp.
Red maple	<u>Acer rubrum</u>
Red mulberry	<u>Morus rubra</u>
Red-osier dogwood	<u>Cornus stolonifera</u>
Reed canary grass	<u>Phalaris arundinacea</u>
River birch	<u>Butula nigra</u>
River bulrush	<u>Scirpus fluviatilis</u>
Rush	<u>Juncus</u> spp.
Salt cedar	<u>Tamarix gallica</u>
Saltgrass	<u>Distichlis spicata</u>
Saltmarsh bulrush	<u>Scirpus robustus</u>
Saltmeadow cordgrass	<u>Spartina patens</u>
Sandbar willow	<u>Salix interior</u>
Sea-blite	<u>Suaeda californica</u>
Sedges	<u>Carex</u> spp.
Shagbark hickory	<u>Carya ovata</u>
Shore grass	<u>Monanthochloe littoralis</u>
Shumard oak	<u>Quercus shumardii</u>
Slender pondweed	<u>Potamogeton pusillus</u>
Smooth cordgrass	<u>Spartina alterniflora</u>
Soft bulrush	<u>Scirpus validus</u>
Soft rush	<u>Juncus effusus</u>
Southern dewberry	<u>Rubus trivalis</u>
Southern red oak	<u>Quercus falcata</u>
Stiff dogwood	<u>Cornus foemina</u>
Sugarberry	<u>Celtis laevigata</u>
Swamp privet	<u>Forestiera acuminata</u>
Sweetgum	<u>Liquidambar styraciflua</u>
Sycamore	<u>Platanus occidentalis</u>
Tamarisk	<u>Tamarix</u> sp.
Texas bluestem	<u>Andropogon</u> sp.

<u>Common Name</u>	<u>Scientific Name</u>
Timothy	<u>Phleum pratense</u>
Toothache tree	<u>Zanthoxylum clava-herculis</u>
Tufted hairgrass	<u>Deschampsia caespitosa</u>
Water hickory	<u>Carya aquatica</u>
Water hyacinth	<u>Eichornia crassipes</u>
Water oak	<u>Quercus nigra</u>
White Dutch clover	<u>Trifolium repens</u>
White oak	<u>Quercus alba</u>
Widgeongrass	<u>Ruppia maritima</u>
Wild rice	<u>Zizania aquatica</u>
Willow oak	<u>Quercus phellos</u>
Winged elm	<u>Ulmus alata</u>

Fauna

Alligator	<u>Alligator americanus</u>
Anhinga	<u>Anhinga anhinga</u>
Belding's savannah sparrow	<u>Passerculus sandwichensis beldingi</u>
Black-necked stilt	<u>Himantopus mexicanus</u>
Black skimmer	<u>Rynchops niger</u>
Bobwhite quail	<u>Colinus virginiana</u>
California least tern	<u>Sterna albifrons browni</u>
Canada goose	<u>Branta canadensis</u>
Caspian tern	<u>Sterna caspia</u>
Common tern	<u>Sterna hirundo</u>
Fox squirrel	<u>Sciurus niger</u>
Gray fox	<u>Urocyon cinereoar genteus</u>
Gray squirrel	<u>Sciurus griseus</u>
Herring gull	<u>Larus argentatus</u>
Hooded merganser	<u>Lophodytes cucullatus</u>
Laughing gull	<u>Larus atricilla</u>
Least tern	<u>Sterna albifrons</u>

<u>Common Name</u>	<u>Scientific Name</u>
Light-footed clapper rail	<u>Rallus longirostris levipes</u>
Mallard	<u>Anas platyrhynchos</u>
Muskrat	<u>Ondatra zibethicus</u>
Opossum	<u>Didelphis virginiana</u>
Rabbits	<u>Sylvilagus spp.</u>
Raccoon	<u>Procyon lotor</u>
Red fox	<u>Vulpes fulva</u>
Red wolf	<u>Canis niger</u>
Ring-billed gull	<u>Larus delawarensis</u>
Royal tern	<u>Sterna maxima</u>
Sandwich tern	<u>Sterna sandwichiensis</u>
White-tailed deer	<u>Odocoileus virginianus</u>
Wild turkey	<u>Melaeetus gallopavo</u>
Wood duck	<u>Aix sponsa</u>
Wood stork	<u>Mycteria americana</u>
Yellow perch	<u>Perca flavescens</u>

APPENDIX B: MICHIGAN DEPARTMENT OF NATURAL RESOURCES
RESTORATION AND DEVELOPMENT PLAN

1. This appendix was taken directly from the draft EIS and deals only with the marsh restoration plan; it is copied exactly as originally presented with purposes of consolidating the plan ideas into one section so that it could be more easily understood in its entirety.

Project Scope

Marsh restoration

2. The project proposes the restoration of 1900 acres of marsh in three separate compartments by the construction of 10,000+ ft of dike involving the excavation and deposition of one million cu yd of dredged material. This project will also involve the installation of water control structures (tubes, gates, weirs, pumps) and the temporary dewatering of now existing lake bottom (former marsh) to stimulate growth of aquatics by water control and/or planting). Dewatering of the marsh will necessitate the rerouting of Mouillee Creek, Bad Creek, and the Lautenschlager Drain into Lake Erie by other routes. Proposed water control structures will allow for drainage of these waters into Lake Erie or through the restored marsh in the future.

3. The restored marsh will be maintained by a flow of water from Lake Erie through open control structures. These structures duplicate in cross section the former creeks and channels that were existing in this marsh in the early 1950s. Natural levels will be manipulated only if extended drastic levels of Lake Erie (high or low) occur that would severely damage the marsh.

Agricultural program

4. Development of 900+ acres of floodable farm fields with agricultural history (upland) by construction, reconstruction, or repair of 35,000 ft of low level dike. Water control structures such as tubes, gates, and pumps will serve dual use for flooding or dewatering of these units.

5. These agricultural units will be developed for the feeding of migrant and local waterfowl and will be managed as refuges and public hunting zones. Other than waterfowl and hunter use, these areas will be available for nonconsumptive uses such as bird watching, educational programs, etc.

Development and management of the
confined disposal area, Barrier
Island confined disposal area,
Barrier Island

6. The long-range management of the Barrier Island shall include the development of waterfowl and upland nesting cover on the surface of the completed facility, day use for the public in the form of shoreline fishing, shoreline hunting, and regulated bird watching and other out-of-doors activities in designated and scheduled areas.

Environmental Impacts of Proposed Actions

7. This section will develop four of the items listed in Project Scope and addresses the environmental impacts of these proposed actions. The scope of the project was segmented into five major areas of proposed action:

- a. Marsh restoration proposal.
- b. Agricultural and moist soil program proposal.
- c. Barrier Island management proposal.
- d. Wetland ecological center and game area headquarters development.
- e. Public use facilities proposal.

8. Under each project the impacts of the proposed action will be discussed as it concerns natural environment, geological impact of dike placement, impacts from construction and operation, drainage, currents, water quality, effect on fish, effect on wildlife and vegetation, effect of confined material on diked and adjacent areas, and impact of recreation. Social and economic impacts of the proposed action and summary of beneficial and adverse impacts and mitigation are dealt with as pertains to the project as a whole.

Impacts on the physical environment

9. Marsh restoration proposal. This segment of the project proposes to develop dikes, causeways, water control structures, canals and channels, manage water levels, establish nesting cover, and manage the land to restore the quality of wet marsh that existed in the early 1950s. The Pointe Mouillee marsh in this period is considered to have had a near optimum interspersion of open water and emergent vegetation, as well as excellent amounts of submerged aquatics.

a. Construction. Project 1 - North Refuge Dike and North Causeway.

- (1) Purpose of action. This development was proposed to furnish roadway access for the contractor to construct the north or Phase II part of the confined disposal facility Barrier Island. This structure is also part of the proposed MDNR overall plan for permanent water management potential for the restoration of the marsh.
- (2) Means of accomplishment. This point has a triple benefit action:
 - (a) The Phase II contractor has an opportunity to pick a route of less hauling distance than through Phase I (south part of dike) with a reduction of energy consumption, time, and disturbance.
 - (b) The MDNR has an opportunity to have a planned structure completed at little or no cost to the people of the state of Michigan in the form of north causeway, and obtain much needed repairs to the north dike of the refuge that has been badly eroded by wave action.
 - (c) Disposal of spoils in the excavated borrow area for bed clay on the east side of the MDNR refuge will diminish the amount of spoil programmed for the containment facility and will lengthen the life by at least one year.
- (3) Permit requirements. Corps of Engineers 404 and State of Michigan Act 346 and Act 247 permits are required for the proposed action. A permit has been issued by both agencies under a joint application for this project. Work is under way (*Editor's note: causeway was completed and in full use in August 1979*).
- (4) Scope of activity. The north causeway construction is new work involving 3600 li ft of dike and roadway. The upgraded refuge dike is a widening operation involving 7500 li ft of existing barrier embankment.

The acreage of new bottom covered by the north causeway is approximately 7.5 acres, with 2.6 acres being covered by the widening of the existing refuge dike. Top elevation of dike and causeway is 576.1 ft or 7.5 above low lake water levels.

- (5) Type of material, volume, and erosion protection.
All construction will be with parent bed clay excavated and spread dry obtained from the east corner of the refuge (10 acres). Estimated 250,000 cu yds to be excavated and spread. This borrow area is to be used as future disposal site for nonpolluted organic material from Phase II dike alignments as part of permit authorization. The north and south faces of the north causeway will be protected against wave erosion by riprap and quarry stone to a depth of 12-15 inches to low lake water level (568.6 ft). The top of the upgraded dike will be surfaced with 12 inches of quarry run crushed stone. Future plans by MDNR include facing the north face of this dike with broken concrete rubble to protect against wave erosion from northern winds. All exposed soil areas will be seeded to grass and legumes immediately to stabilize and prevent erosion.
- (6) Structures. Five 4-ft corrugated steel pipes are programmed to be installed in the north causeway. These water control tubes are to be installed in the old Highwater Mark Channel and old Vermet Creek Channel to duplicate the former entrances for water flow into the marsh. The cross section of these five tubes equals 12.56 sq ft/pipe or 62.8 sq ft total. This figure equals the old Highwater Mark and Vermet Creek Channels cross section totals as observed in the early 1950s. Bottom elevation of the pipes is to be at the existing bottom elevation of the existing channels. Water control gates are to be installed on the marsh side of the pipes to lower the incidence of ice damage. These gates are necessary to establish water control for dewatering of the marsh for vegetation restoration and will be supplied by MDNR.
- (7) Impacts. Negative impacts of construction are:
 - (a) Ten acres of bottomland and marsh will be lost in construction of the causeway and dike restoration.
 - (b) There will be a temporary water quality degradation by turbidity during the construction phase.
 - (c) There will be a modification of the organic bottom profile during dike construction by displacement.

- (d) The activity will displace fish and invertebrate use of the covered bottomlands.
- (e) Some boating access will be eliminated by this construction.

Positive impacts of construction are:

- (f) Portions of the lost bottomland will be converted to shoal area and upland which will furnish nesting cover for waterfowl and related wetland species, as well as nursery habitat for fish.
- (g) The north causeway and reconstructed dike will protect the restored marsh portions of the game area from erosive wave action, ice action, and related turbidity (Smith 1978).
- (h) This construction will provide a water control mechanism that will allow the restoration of the marsh to proceed on a scheduled basis rather than at the unpredictable whims of nature with its high water and low water cycles.
- (i) The causeway on a permanent basis will provide roadway access to the confined disposal area for future maintenance of these structures. The State of Michigan will be charged with future maintenance of this disposal area when the project is complete. Shallow water adjacent to the disposal area precludes the use of barges for dike maintenance.
- (j) This construction will provide a future recreational site for bank fishing opportunity. Fish will be attracted at the sites of water movement, especially in the pipe and channel areas.
- (k) Disposal of spoils in the excavated borrow areas on the east side of the refuge will reduce the amount of spoils to be deposited in the confined facility being constructed in Phases I and II, and will lengthen the life of the facility.
- (l) Some bare ground nesting sites may be made available for such species as gulls, terns, shorebirds, on the surface stone (Soots and Landin 1978).
- (m) The installation of the water control structures will provide for a flow through capacity that will duplicate the water movement in the early 1950s (Lunz et al. 1978).
- (n) Reduction of casual boating will reduce human disturbance and provide for more nesting and use by wildlife.

b. Project 2 - Center Cross Dike, Site A; Constructed Nesting Islands, Site B; and Restoration of the Borrow Area in the Refuge, Site C.

- (1) Purpose of action. This development is proposed to provide additional water control for marsh restoration, enhance nesting opportunity for waterfowl and upland species, enhance the fish use of the marsh by providing deep water channels and shoal areas in the vicinity of the nesting islands, and restore the borrow area in the refuge.
- (2) Means of accomplishment. This project has a triple benefit action:
 - (a) The Phase II contractor has an opportunity to dispose of unpolluted bed clay spoils in the construction of the cross dike (Site A - 443,000 cu yds) and disposal of 373,000 cu yds of soft and/or organic material within the bed clay confinement dikes of the four nesting islands (Site B) and the borrow area (Site C).
 - (b) The MDNR has an opportunity to have these planned structures completed at little or no cost to the people of the State of Michigan.
 - (c) Disposal of spoils on the proposed cross dike area, nesting islands, and borrow area will reduce the amount of spoils going into the confined disposal area, thus lengthening its life.
- (3) Permit requirements. The same permits as stated in paragraph 8a3 apply here as well, and have been applied for.
- (4) Scope of activity. The proposed cross dike and nesting islands are new work involving 5500 li ft of dike and four nesting islands. The acreage of new bottomlands coverage will be 50.5 acres by the dike and 16 acres by the islands. Top elevation of islands will be 10+ ft above low lake water levels. Site A will have a cross dike profile of 20:1 or 400 ft wide at the base. The average upland will be 30.0 acres. The remaining 20.2 areas will be shoal water area. Site B will have nesting islands constructed in the restored marsh with one island north of the cross dike and three south of it. They will be constructed with an outer perimeter of bed clay and will be dug on site with a borrow ditch created on the outside edge of the island. Islands will basically be round (470 ft wide at base and 10+ ft high with a 3:1 slope). A maximum of 16 acres will be covered by the islands (12 upland acres and 4 shoal area acres). In Site C

the bed clay borrow area for the north causeway will be restored to bottomland elevation and the existing borrow ditch adjacent to the east dike will be filled. This fill will be 173,000 cu yds of soft material and it will be 2 ft lower than the existing dikes. The intent of this construction is production of shallow marsh and shoal water areas. All spoil materials are to be hydraulically moved with the exception of bed clay confinement dikes for island construction.

- (5) Types of material, volume, and erosion protection. In Site A all material for the cross dike will be parent bed clay and will be 443,000 cu yds. Upland areas will be planted with grasses and legumes; shoal areas will be planted with emergent aquatic vegetation. The slopes will be riprapped for wave erosion protection if the north causeway is deemed by the permit to be a temporary structure. Site B dikes will be parent bed clay with interior fill of soft material (200,000 cu yds). Upland areas will be seeded with grasses and legumes and shoal areas will be planted with emergent aquatic vegetation. The north island slope will be riprapped if the north causeway does not remain in place. Material for Site C will be soft (173,000 cu yds), and planting will be the same as indicated above.
- (6) Structures. Eleven 3-ft corrugated steel pipes will be installed by the MDNR in the cross dike to facilitate water movement with the restored marsh. Each pipe has a cross section of 7.07 sq ft for a total of 77.8 sq ft for all pipes. This total exceeds the necessary cross section needed to match the five 4-ft pipes in the north causeway. Pipe inverts will be installed at the best elevations for most beneficial movement of water and fish life. Because of the width of the cross dike (400 ft average), the pipe sites will be indented to make for a maximum length of pipe of about 100 ft. Pipes will be installed after the cross dike has been constructed and had time to consolidate. Three pipes will be placed in the west half of the dike and eight in the east half. Specified sites will be determined by a joint committee of Corps of Engineers, U. S. Fish and Wildlife Service, and MDNR personnel in the summer of 1981, with installation to be done by MDNR shortly thereafter. MDNR considers the cross dike and north causeway to be permanent and essential parts of the marsh restoration effort and essential to the future operation, protection, and maintenance of the marsh and spoil disposal containment area. Without a permanent north dike, the completed spoil containment area will further

accelerate the destruction of the marsh by concentrating littoral forces through the marsh system. The MDNR will apply 350,000 cu yds of riprap material to the cross dike should the north causeway be removed, as well as to the side of the north nesting island.

(7) Impacts. Negative impacts of construction are:

- (a) Thirty acres for the dike and 12 acres for the islands will be lost from existing bottomlands.
- (b) There will be a temporary reduction in water quality caused by construction within a closed system. The only real outlets to Lake Erie are through north and south causeway pipes and the construction opening in the disposal site. Sites will be monitored and silt screens will be installed if necessary. Gates in the causeways can be closed.
- (c) A modification of the bottom profile during construction will result from displacement.
- (d) The construction activity will displace fish and invertebrates on the covered bottomlands.

Positive impacts of construction are:

- (e) The covered bottomlands will be replaced by upland which was drowned in past years (Jackson's Island, East Lead Islands I and II, and Mouillee Bay Islands I and II).
- (f) Bottomlands will be converted to shoal areas and uplands to provide habitat for nesting as well as brood rearing and spawning habitat.
- (g) The cross dike and islands will give more protection to the restored marsh area from erosion, wave action, ice action, littoral movement of bottom sediments, and related turbidity.
- (h) Cross dike will compartmentalize the restored marsh and allow immediate water control and restoration of Section 1.
- (i) Disposal of spoils in Sites A, B, and C will extend the life of the confined disposal site.
- (j) Hydraulic movement of spoils will contribute in a positive way to adding nutrients to the marsh area (Lunz et al. 1978).
- (k) Excavations adjacent to the nesting islands will furnish deep water areas for larger game fish during periods of water level fluctuations caused

by wind tides in Lake Erie. This deep water area will also enhance the angling opportunity in the marsh.

- (1) The cross dike will furnish an alternate access route to the disposal site dike for future maintenance.

c. Project 3 - South Causeway. This causeway was constructed under the permit for Phase I development of the confined disposal area and is covered by DD EIS (1974). Water control for this road is 43 6-ft pipes and 2 10-ft pipe arches. Both are without gates at the present time, but the EIS (1974) stated that gates would be installed. It is assumed that gating of these structures will be part of the construction costs of the confined disposal facility and will be borne by the Corps of Engineers. These should be in place to conform with the schedule of water management as outlined by the State of Michigan.

d. Project 4 - Relocation of Lautenschlager Drain, Mouillee Creek, Mouillee Creek/Old Channel Containment, Marsh Unit No. 4, and Bad Creek.

- (1) Purpose of action. MDNR proposed to gain temporary water control of streams entering the Mouillee marsh restoration project area to allow for water management (drawdown necessary to reconstruct the marsh), to provide a reliable water source through a deep water channel to Lake Erie for water management of the marsh and upland agricultural units, and to provide an alternate deep water boat access channel to the deep waters of Lake Erie for small boats.
- (2) Means of accomplishment. The MDNR is anticipating an application for Corps of Engineers 150 program funds under Phases I and II construction of the confined disposal facility for restoration of the inner marsh. *(Editor's note: no such funds under Section 110 legislation presently exist.)* This will further implement the suggestions of the EPA--the MDNR receive a firm commitment from the Corps of Engineers for restoration of the Pointe Mouillee marsh.
- (3) Permit requirements. Wetlands regulations Section 404, plus Michigan regulations Acts 346 and 247, are required and have been applied for.
- (4) Scope of activity. All construction will be new work involving the relocation of existing creeks and drains.
 - (a) Lautenschlager Drain relocation. This drain enters the project area in the northwest corner and flows in the southeasterly direction to join

with the waters of Mouillee Creek, a distance of approximately 1-1/2 miles from the Dixie Highway. It is proposed to relocate this drain to rejoin Mouillee Creek at a different site. The new channel will be about one mile long and be 100 ft wide; the project will cover 13 acres, with the adjacent dikes at 10+ ft above lake levels.

- (b) Mouillee Creek relocation. Mouillee Creek enters the project area in the upper west side near Labo Road and Dixie Highway and flows in an easterly direction. It empties into the Mouillee marsh and Lake Erie. It is proposed to be relocated so that it flows southward along the east side of Roberts Road to empty into Lake Erie at the southwest end of the disposal project. This route would bypass the solid waste landfill at Labo and Roberts Roads. An alternate route through the west edge of the landfill is also being considered. The new channel will be 2-1/2 miles long and 160 ft wide. Dike elevation will be 10+ above lake levels. The proposed berm along Roberts Road will vary in width from 30-75 ft with the channel and dike alignment being meandered to form a more pleasing stream or channel. The channel depth will be a minimum of eight ft for boat access and for deep water fishing. All dikes and construction will take place eastward of Roberts Road with the road drainage ditches being left undisturbed. Bad Creek located near the junction of Roberts and Reaume Roads will be relocated as its intermittent flow will be channeled into the relocated Mouillee Creek.
- (c) Mouillee Creek/Old Channel containment. A containment channel is proposed to allow for water management of the flows of Mouillee Creek and Lautenschlager Drain. By diking and the installation of water control gates, the flow of water can be directed either into the restored marsh to the east or be directed south into the relocated Mouillee Creek channel in a southerly direction to Lake Erie. This sump channel would also allow for water management of all the proposed marsh sections and agricultural sections by gravity flow or pumping, as this containment (sump) area would be directly connected to the deeper waters of Lake Erie through the relocated Mouillee Creek channel and the marsh sections 1, 2, 3, and 4 by pipes and gates. This sump will involve 1-3/4 miles of dikes and related borrow

area, with each dike about 45 ft wide. The dikes will cover 9-1/2 acres and have a top elevation of 10+ ft above lake levels. The borrow area will be from the old Mouillee Creek bayou with variable width and depth depending upon the amount of borrow material needed.

- (d) West Dike Marsh Unit (Section) No. 4. Additional diking is recommended to construct an additional managed marsh unit. In order to maintain this area as a functioning marsh, it must be isolated from the proposed agricultural units and the old Mouillee Creek containment unit. This area is located in the northcentral portion of the state game area. The proposed new diking would be located primarily on the west side of the unit, as the east side is presently contained by dikes of marsh unit 3, and the south side will be contained by the proposed old Mouillee Creek containment dike. The new dike would be about one mile long and by 90 ft wide. It will cover 11 acres and its top elevation will be 10+ ft above lake levels. The borrow area will be to the west of the dike, with both the dike and borrow being on upland sites.
- (e) Bad Creek relocation. See Mouillee Creek relocation.
- (5) Type of material, volume, and erosion protection.
 - (a) Type of material. All materials that will be excavated, with the exception of the old Mouillee Creek containment dike, will be bed clay with little overburden of silt or topsoil. The containment excavation will involve more silt and peat than the rest, but no more than 2-1/2 ft in depth over bed clay.
 - (b) Volume. All proposed dikes have similar cross sections and are 45 ft wide with 2:1 to 3:1 side slopes and are 10+ ft above lake levels. The average volume of fill per 11 ft is 6.5 cu yds. Total length of dikes proposed is 6.75 miles. Total cu yds to be moved are 231,660.
 - (c) Erosion protection. In all projects proposed excavation can be performed under dry conditions as the construction sites can be isolated from existing drains, creeks, and marshes. Silt traps will be constructed in suitable areas, along with the vegetation that will grow in the excavated ditches to control water turbidity. Areas of new construction will be seeded with

appropriate grasses and legumes to control water and wind erosion and to stabilize soil.

(6) Structures.

- (a) Lautenschlager Drain. No structures.
- (b) Mouillee Creek relocation. Structures that must be installed in this project include: Area E - a large pipe arch or bridge over relocated Mouillee Creek that will be the same height as the Dixie Highway bridge for boat access purposes; Area E1 - stone breakwater may be indicated at the mouth of the relocated Mouillee Creek where it enters Lake Erie.
- (c) Mouillee Creek/Old Channel containment. Area D needs a radial water gate 4 x 10 ft or equivalent in 4-ft pipes and gates; Area F needs two 3-ft pipes with gates; Area G needs five 3-ft pipes with gates; and Areas H and I need one wind operated pumping facility with 10,000 GPM capacity each.

(7) Impacts. Negative impacts of construction will be:

- (a) Some land use changes are proposed. In the Lautenschlager Drain, Mouillee Creek relocation, and marsh unit 4, the total area effected is 72.5 acres. The Mouillee Creek containment area will be converted from marsh to upland.
- (b) There will be a temporary and minimal effect on water quality from outflow waters in the newly constructed ditches and channels when put into use. The adverse effects can be controlled by all construction being accomplished in dry conditions followed by the immediate seeding of raw earth from construction activity.
- (c) The activity will displace some wildlife along the proposed construction routes, but it will become occupied again once vegetation is reestablished.
- (d) The action will alter boat use that has been established along old water routes.
- (e) There will be an increase in noise from equipment operation and temporary human and equipment activity in the construction area.
- (f) A portion of water flows from Mouillee Creek and Lautenschlager Drain will have the opportunity to flow directly into Lake Erie through the relocated Mouillee Creek. There will be no change from present flow patterns.

Positive impacts from construction will be:

- (g) A high quality marsh will be created by water control in marsh unit 4.
- (h) Relocation of Mouillee Creek and Lautenschlager Drain will provide a reliable water source for the water management program of the developed marsh and agricultural units and will also provide a protected deep water boat channel to Lake Erie.
- (i) The relocated creek and drain will provide a good quality deep water bank angling fishery that does not presently exist in the area with the exception of some portions of the Huron River.
- (j) The Mouillee Creek containment channel will be key to water management of the marsh units and the agricultural areas, furnishing water control by gravity flow and mechanical pumping.
- (k) Sediment basins in the proposed creek and drain location will provide water quality of the portion of water that will flow down this creek into Lake Erie.
- (l) The increased channel in the creek and drain will increase flood water discharge capacity.

e. Water management.

- (1) Goals. It is important that complete water management be available for the proposed marsh restoration program. The projects that were explained and detailed above allow for the temporary diversion of water flows from the marsh allowing for the creation of a habitat suitable for the restoration of the emergent and submerged aquatics that made up this former high quality marsh. The project goal is to establish an interspersed of emergent aquatics and open water on a 1:1 ratio of emergent cover and water surface. The emergent cover should contain narrow leaf cattail, bulrush, burreed, duck potato, pickerel weed, water smartweed, and others. The open water should contain the following submerged aquatics: wild celery, sago pondweed, other pondweeds, naiads, coontail, milfoil, water lilies, and others. This designed marsh should be attractive to both diving and dabbling ducks, rails, coots, gallinules, wading birds, songbirds, pheasants, muskrats, raccoons, minks, and other marsh animals. The marsh will also furnish habitat for pipe, perch, bluegill, sunfish, crappie, bullheads, bass, carp, dogfish, gar, and others.

The volume of water flow in Lautenschlager Drain, Mouillee Creek, and Bad Creek is very low except during the spring runoff period. All three water courses exist as drowned creeks subject to water movement of wind tides in western Lake Erie. The temporary diversion of the flow of these drains through the re-located Mouillee Creek channel should not alter the water quality of the outflow of Lake Erie because there is virtually no existing aquatic plant growth to provide treatment under existing conditions. Under further restored conditions the drainage flow will be split between the old channel into the restored marsh and the new channel to Lake Erie. It is anticipated that aquatic plant growth in the more reliable water habitat of the new channel will provide for absorption of nutrients from that portion of the flow following this water course.

- (2) Techniques and schedule. Marsh Unit 1: It is a well-established fact in the wetlands literature that a rapid expansion of emergent plant communities is accomplished only by exposure of bottom soils by water drawdown. Moist mud flats particularly silts, clays, and organics provide favorable germination sites for the seeds of cattails, bulrushes, bur-reeds, sedges, and some grasses. Submergents will germinate and grow in shallow clear waters.
- (a) Dewater marsh unit 1 in the spring of 1982, depending upon disposal site contractors' progress.
 - (b) Programmed seeding of emergents and/or submergents if required based upon tests of seed stock.
 - (c) Gradual restoration of shallow waters of new growth proceeds, possibly the same summer as initial drawdown.
 - (d) Repeat drawdown in springs of 1983 and 1984 if necessary depending upon response of vegetation in 1982.
 - (e) Operate restored marsh in 1985 with north causeway pipes opened to allow water level fluctuation with Lake Erie.

Marsh Unit 2:

- (f) Repeat points (a-e) for unit 2.
- (g) An incomplete drawdown of marsh unit 2 is expected because of bottom contours. Pools totalling 200-225 acres will be permanently 18+ in. deep.

- (3) Long-term maintenance. A precise schedule of water level manipulation is not possible to completely predict as there will be a great variation in Lake Erie water levels because of weather, wind, tides, and other factors. If the planted marsh emergent cover increases to 75 percent area coverage, steps will be taken to open the marsh up by artificially increasing water levels. Loss of emergent vegetation to the point of 66 percent open water would indicate that dewatering of the area for marsh restoration should be conducted. Variance within these limits would be acceptable. Flow through management would be available by use of wind pumps to raise water levels during low lake cycles. Marsh units 1, 2, 3, and 4 can be managed together or as separate units depending upon need. Fish values will be addressed in all water level manipulation.
- (4) Impacts. Negative impacts of management would be:
- (a) Dewatering of the marsh units will temporarily remove all fish habitat and alter wildlife use. Fish will be allowed to escape.
 - (b) There may be a question of the quality of water that will be drained or pumped from the marsh sites into Lake Erie. This is essentially Lake Erie water being returned to Lake Erie and will be of little difference than what is taking place now on high and low levels caused by wind tides.
 - (c) Exposed mud flats and shallow water may furnish a medium that could generate botulism growth in hot summer weather; however, the drawdown will be an early season drawdown of short duration. If botulism growth does develop, the capability of immediate reflooding can alleviate the situation. Present waterfowl use is very light, so the number of birds that may be affected is very small. Other management techniques such as harassment, scare techniques are available to minimize the problem.
 - (d) In periods of extreme lake levels, the flow-through principle will be altered to restrict marsh damage. During this period of temporary closure to Lake Erie waters, fish movement from the lake to the marsh or vice versa will be stopped. Pumping into the marsh during low lake levels may generate some flow through to Lake Erie and allow for some fish movement.

Positive impacts of management would be:

- (e) Water management will allow for the restoration phase and long-term maintenance of the marsh aquatic plant communities which provide habitat for fish, wildlife, aquatic invertebrates, as well as providing water purification potential by sediment control and withdrawal of nutrients.
- (f) Although water management may at times temporarily disrupt interchange of fish between the marsh and Lake Erie, it will provide an angling opportunity by providing deep water habitat for larger game fish species. The natural marsh as it existed subject to the fluctuations of Lake Erie did not provide the type of habitat necessary for the maintenance of resident populations of large game fish.
- (g) The mud flat stage of drawdown will furnish a large amount of temporary habitat for shorebird type wildlife as well as terrestrial wildlife species.
- (h) Periodic drawdown for marsh management will expose bottom organic materials to oxygen and sunlight for decomposition into basic nutrients, furthering availability to plants, fish, and aquatic invertebrates.

10. Agricultural and moist soil programs proposal. This segment of the project proposed to develop approximately 1140+ acres of upland agricultural land as an integral part of waterfowl management on the Pointe Mouillee State Game Area. This phase is basically considered a MDNR project, except in areas where the units are contiguous with or influence the development of the marsh restoration in marsh units 1, 2, and 4.

a. Construction.

- (1) Purpose of action. These units will be developed to furnish food for migratory and local waterfowl by the growing of agricultural crops by accepted farming practices and/or moist soil management. Part of the management includes shallow temporary flooding in the fall for waterfowl use.
- (2) Means of accomplishment. The development of this agricultural and moist soil portion will be primarily a MDNR activity, except in those areas where development is contiguous with the marsh restoration project.

- (3) Permit requirements. Development of this fallow upland with an agricultural history above the high water mark will not require Corps of State of Michigan permits. However, all developments will be cleared with the concerned units of government for necessary clearance for work.
- (4) Scope of activity. In addition to the developments already outlined in the marsh restoration phase, five agricultural units are proposed for development.
- (a) Unit 1. Approximately 225 acres. Construction of 5200 ft of new low level upland dike, plus water control pipes and gates.
- (b) Unit 2. Approximately 225 acres. Construction of 500 ft of new low level upland dike, plus water control pipes and gates.
- (c) Unit 3. Approximately 300 acres. Construction of 5200 ft of new low level upland dike, plus water control pipes and gates.
- (d) Unit 4. Approximately 275 acres. Construction of new and rebuilding old section of upland dike, a distance of 3700 ft, plus water control pipes and gates.
- (e) Unit 5. Approximately 165 acres. All dikes and water control structures in place. No new work.
- (f) Totals. Acreages equal 1140 and dike footages equal 14,600. Pumping facilities are involved in the Old Mouillee Creek containment section so no new pumps are required.
- (5) Type of material, volume, and erosion protection. Construction of low level upland dikes in the agricultural units will be from basic bed clay. The total length of 14,600 ft of dike will equate to 73,000 cu yds of earth moved. All dikes will be constructed dry and seeded to grasses and legumes to stabilize and control erosion. Dike heights will be built to an elevation to prevent flooding of crop lands by wind tides or seches.
- (6) Structures. Covered in (4) above.
- (7) Impacts. Negative impacts of farming activities would be:
- (a) There will be some existing upland habitat that will be permanently changed by the construction of ditches or borrow areas associated with dike construction. This land will total about 10 acres.

- (b) There will be a change in upland use by wildlife in the transition from woodlot, brush, grassland to agricultural, or moist soil management. The change will not be great to terrestrial upland wildlife species.
- (c) Activity and noise associated with machinery and personnel travel during the building phase.
- (d) Provide means to manage the upland areas for high quality, reliable, high volume food and cover for waterfowl and related upland game and nongame species.
- (e) By providing the means to dewater and flood by use of pipes, gates, dikes, and pumps, reliable food supplies can be raised by agricultural practices and made available by flooding to waterfowl. An additional 1100+ acres of temporary wetland is added to the 2000 acres of marsh for use by migrating waterfowl in the spring and fall. Shallow shoal areas and mud flats associated with flooding will furnish several hundred acres of excellent habitat for wading and shorebirds.
- (f) Wetland habitat will be created for the use of endangered species such as the Kirtland's water snake, northern copperbelly water snake, spotted turtle, marsh plant, barn owl, and American bittern.

b. Land and water management. The typical land management of these agricultural type uplands will be to grow crops for wildlife. Cropping may be entirely by state personnel and equipment or be accomplished with sharecrop agreements with local farmers. The lands will be worked with conventional farming equipment to grow crops such as corn, wheat, buckwheat, millet, sorghum, and other small grains. Approved herbicides and fertilizer will be used for optimum crop production or as normal farming practices. Crop rotation and good land use principles will be observed. All state planted or state share of crops will be left standing in the fields for wildlife use. These lands will be flooded in the fall to create an aquatic environment for waterfowl feeding and use.

(1) Impacts. Negative impacts of management would be:

- (a) Use of land for farming will reduce some of available brush and grasses sites for nesting cover for waterfowl and upland species of wildlife.

- (b) If water management is not correct and dewatering flows are directed into Lake Erie, nutrients from the farm fields will be a source of pollution. Water from the fields will be directed to flow through the restored marshes in all cases.

Positive impacts of management would be:

- (c) Making farm crops available to waterfowl will greatly increase the feeding capacity of the area as compared to natural available foods. Highly nourishing grains will improve condition of migrant waterfowl and will be especially valuable in the spring for use by breeding females.
- (d) The availability of a mixture of grain and natural marsh foods and marsh cover will reestablish the game area to equal or exceed its former status as a waterfowl area. This reestablishment will restore the former hunting opportunity as well as other nonconsumptive uses, such as viewing, photography, etc., at the nature center.
- (e) Use of the area by people will bolster the local economy by retain sales of food, lodging, and supplies for hunters, fishermen, and other users.
- (f) A high quality natural area will be made available for use by people of the metropolitan areas of Detroit, Toledo, and other nearby urban areas.

11. Barrier island management proposal (700 acres). The State of Michigan DNR will be charged with the maintenance and management of the Barrier Island (diked disposal site) upon completion of the polluted spoil disposal program by the Corps of Engineers. This completion date may be approximately 10 years from the present or 1989. Information from the Corps indicates that the spoil materials in the confined disposal area will not be capped with an unpolluted fill and the surface of the disposal area will be left in an irregular and ungraded state. This condition will result in natural ponding with higher, better drained upland areas. This will be the condition of the Barrier Island when it is turned over to the State of Michigan. At this time, it is predicted that there shall be a formation of vegetated wetland areas, interspersed with grassy, weedy, or woody vegetation upland sites on the older fill areas, similar to the type of habitat that developed on

Seaway Island on the St. Clair River Cutoff Channel. A natural drainage system from rainfall will have developed. The type and character of proposed development and management of wildlife and human recreation will depend on the toxicity of the fill on the surface of the island at the time of the acquisition by the state, the topography of the fill, the condition of the quality of outflow runoff water, and the vegetative cover. The following development and management proposals are mainly conceptual at this time and must be tailored in the future to the existing conditions and calculated impacts of each action.

a. Development.

- (1) Wetlands. No mechanical or physical movement of soil is contemplated to construct wetland areas. Wetlands created by the natural pattern of spoil disposal will be left in place. One hundred acres may be produced naturally.
- (2) Nesting areas. Creation of grassy herbaceous cover for nesting and small game habitat will be encouraged on the better drained areas of the island surface. Surface soil preparation will be made to encourage the germination of planted or volunteer seeds of native grasses and legumes. Areas will be mowed to control woody vegetation in most areas, although small brush areas may be encountered for a diversification of habitat (400 acres). Bare ground areas (20 acres) will be maintained or developed for nesting areas for shorebirds, gulls, and terns, and will be scattered throughout the island.
- (3) Crop areas. Some crop areas for the production of small grains are contemplated. Sites, soil conditions, and relationship with water quality will be addressed. As these crop areas are designed to feed waterfowl and resident upland game and nongame species, the transfer of nutrients and/or toxic substances by these plants shall be checked and monitored (100 acres).
- (4) Public use. Public use of this area is expected to be in the categories of consumptive and nonconsumptive activities such as fishing during the spring, summer, and winter; bird watching, hiking, picnicking, etc., during spring and summer; and waterfowl hunting during the fall. We would expect to construct a controlled access road from the mainland to the island and a controlled access service road on the island. Parking lots, trash containers, toilets, and

pull off points would be constructed to accommodate vehicles and people in season. Bank fishing and shoreline hunting blinds are proposed as some activities to be allowed and encouraged in the use of this facility (80 acres total).

b. Management.

- (1) Wetlands. The wetland or ponded areas will be left as they were developed by the Corps. No attempt will be made to channelize or manage the natural outflow of surface water. In DD EIS (1974) as pertains to the confined disposal facility at Pointe Mouillee, no serious problems in water quality of runoff water was presumed to take place when the facility was completed. As MDNR does not plan to alter this drainage pattern, it does not plan to assume the responsibility of the water quality of this runoff unless this quality is effected by the planting of herbaceous cover by MDNR.
- (2) Nesting areas. Annual maintenance of the herbaceous cover on the island surface by mowing, seeding, fertilization, etc. Annual maintenance of the bare ground nesting areas by mowing, herbicide, etc.
- (3) Crop areas. Annual farming practices to produce the desired small grains and browse available to wildlife.
- (4) Public use. The overall management of the Barrier Island is planned to be on a controlled access basis, with the maintenance of undisturbed wildlife areas. A "drive-through" concept of use by the public is not contemplated. Routine maintenance of access roads, trash facilities, toilets, blinds, observation sites, picnic facilities, etc., is planned by personnel and equipment of the game area. A state park or recreation area format is not planned.
- (5) Impacts. Construction phases of the 700-acre Barrier Island have been covered in the DD EIS (1974) by the Corps. Impacts discussed below are concerned only with management and subdevelopment after completion by the Corps. Negative impacts of development and management of the island would be:
 - (a) Wetland areas will provide habitat for wetland species of wildlife and invertebrates. These areas will produce habitat for waterfowl broods, used in conjunction with adjacent nesting herbaceous habitat. These wetland areas will be in addition to the permanent wetland or marsh units produced in units 1, 2, 3, and 4 and the temporary (fall and spring) wetlands produced by

the temporary flooding of the proposed agricultural units 1, 2, 3, 4, and 5. These areas are also potential nesting sites for waterfowl such as the redhead, waterbirds such as coots and gallinules, and nongame species such as blackbirds, wrens, shorebirds, etc.

- (b) The herbaceous nesting areas as proposed will be very valuable in the increased production of local upland nesting waterfowl species. A potential of one duckling per acre is possible. Some of these species are: mallards, black duck, blue-winged teal, and green-winged teal. This nesting habitat will be added to that to be produced by the proposed nesting islands in marsh units 1 and 2, the habitat produced by broad causeways and cross dikes that are proposed in the marsh restoration phase and the habitat produced within the proposed upland agricultural fields. Other upland nesting birds and animals will use this herbaceous habitat for nesting and cover. Bare ground nesting areas will be used by such species as shorebirds, gulls, terns, etc. Predatory species such as gulls should be monitored for possible predation on waterfowl nesting and brooding activity. Increase of any vegetative cover on the surface of the island will add to the stabilization of any pollutant or toxic material and restrict the movement by water or wind action.
- (c) Cropping acres will be in addition to that outlined on the proposed agricultural units and will also be an excellent site for the production of green browse for use by local or migrant geese.
- (5) Public use. Controlled public use of the area will have a positive effect on both the local and visiting public. This area will provide some additional bank shoreline and deep water angling that was not present in previous years. The production of cover and food will provide a wildlife viewing opportunity on an area that did not exist before. The proposed shoreline hunting area will provide an opportunity for lake hunting that did not exist since the destruction of the original Barrier Island by high water and wave erosion. Access to the Barrier Island by the general public will provide an association or view of Lake Erie not available at any time in the past.

11. Proposed wetland ecological center, service, area, headquarters, and manager's residence. Funds are available and plans are

underway for the construction of a Wetlands Ecological Center, a game area headquarters and service area, and a game area manager's residence located at the east end of Sigler Road. This is entirely a MDNR sponsored project, with funds being available from the General Fund, Urban Recreation. The site of this proposed development is above the ordinary high water mark and will be constructed on an old upland agricultural site. Filling of the site with clean clay is anticipated to raise all proposed construction above the 100-yr flood level. The development is outlined as follows:

- a. Service area. This complex will be composed of a storage building and office, a parking lot, and a manager's residence. This unit will be the administration and service headquarters for the game areas and will provide storage for equipment, contact with the public, and related functions of the MDNR Wildlife Division. In this urban area, it will be a project asset to have a resident game area manager or other MDNR employee to live on the area and maintain a constant observation of public use and security of state equipment and facilities.
- b. Wetland ecological center. This facility is located to the east of the game area service area. This center will be designed to bring the public closer to and provide a better understanding of the function of a wetland. A headquarters or interpretative center will be built to address the following subjects: wetland ecology, history of the local marsh, history of waterfowling, and related subjects. A museum and auditorium will be built to present these aspects of wetlands. Outdoor displays will be built to include: observation tower, display ponds, nature tracts, managed marshes, shorebird areas, plus related subjects that can be displayed in an outdoor setting.

12. Proposed public use facilities. The public use facilities proposed will include: shooting range, off-road parking lots, fishing berms, small boat launching ramps, trash and toilet facilities, roadside viewing pull-off sites, fishing access pads, and duck hunting sites. The above proposed and existing facilities will be dealt with on a "site" basis, plotted on a map.

- a. Site 1. Existing game area headquarters containing a large parking area, boat launching ramp, flush toilet facilities, trash receptacles, bank angling facilities in the Huron River. Plans are currently being developed to upgrade this facility with new blacktop parking lots and expanded boat launching sites.

- b. Site 2. Proposed wetland ecological center and game area headquarters and service area development sites have been discussed in paragraph 11 above. This site will contain a large parking area, toilet and trash facilities, and controlled public use of observation tower, center building and displays, nature trails, etc. No fishing, hunting, or boat launching is expected as an activity in this controlled area.
- c. Site 3. Shooting range - the MDNR has an existing shooting facility in place at the present time. This area is leased to the Winchester Arms Company for operation. Facilities are available to the public for skeet, trap, rifle, and pistol shooting on a controlled basis.
- d. Site 4. Construction of a facility to include a 60-car parking lot, small boat launching site, vault-type toilet facilities, trash receptacles, and some bank angling berms along Mouillee Creek.
- e. Sites 5, 6, and 7. Construction of 15-car capacity parking areas with vault-type toilet and trash facilities and access to the fishing berms along the west bank of the re-located Mouillee Creek.
- f. Site 8. Construction of a 50-car parking lot, small boat launching ramp, vault-type toilet facilities, and trash cans to be used for access to marsh unit 2 for fishing and hunting.
- g. Site 9. Conceptual development of this site shall include the following facilities for public use: seasonal access road to Barrier Island, central toilet and trash facilities, pull-off viewing sites, parking for bank fishing and water-fowl hunting, gravel or small stone pads in armor stone of the island for fishing, hunting, and small boat launching. Since the topography, contours, and expected changes in off-shore water depths are unknown at this time, only a conceptual plan can be evolved.

APPENDIX C: REVIEW COMMENTS ON EIS FOR RESTORATION
ON THE POINTE MOUILLEE MARSHES

by

Charles R. Lee

1. The EIS has adequately discussed the impacts of dike construction and marsh creation. These aspects were covered very well.

2. The only aspect that needs additional consideration is the disposal containment area on Barrier Island and its management, pages 132 to 140. It is realized that on page 134 it is stated that "the type and character of proposed development and management for wildlife and human recreation will depend on the toxicity of the fill on the surface of the island." From the data presented in the March 1974 EIS for this project, zinc concentration in Detroit River sediment in 1971 was approximately $630 \mu\text{g g}^{-1}$, which was considered above the EPA criteria. Recent data from a WES study shows zinc concentrations in 1977 sediment samples from the Detroit River of approximately $2,000 \mu\text{g g}^{-1}$, which is considerably higher than those observed in 1971. In addition, cadmium concentrations in the 1977 sediment samples were as high as $29 \mu\text{g g}^{-1}$. The WES study evaluated plant uptake of these metals from the Detroit River sediments and indicated that a marsh plant, Cyperus esculentus, did take up elevated levels of zinc and cadmium from these sediments, especially after the sediment was allowed to dry out. The WES study simulated placement of the Detroit River sediment in an upland environment where the sediment would dry out. This simulation would represent the environment that may occur on Barrier Island. Concentrations of cadmium observed in the plants grown in upland conditions were as high as $6.3 \mu\text{g g}^{-1}$. This elevated plant content should be of concern especially if wildlife may feed upon these plants. Therefore, we are concerned about the use of Barrier Island and its management for a feeding area for wildlife in the future.

3. It is suggested that the contaminated sediment placed in the disposal site be covered with uncontaminated sediment. Burial of contaminated sediment with at least 1 m of uncontaminated sediment should minimize plant uptake of toxic metals by grasses. If deep-rooted plants such as trees are allowed to colonize the area, these plants should be monitored for contaminant content to determine the presence of elevated contaminant levels in the plants. If levels of contaminants are found to be low and not elevated, then no additional concern should exist. If plants do contain elevated levels of contaminants, these plants may need to be controlled.

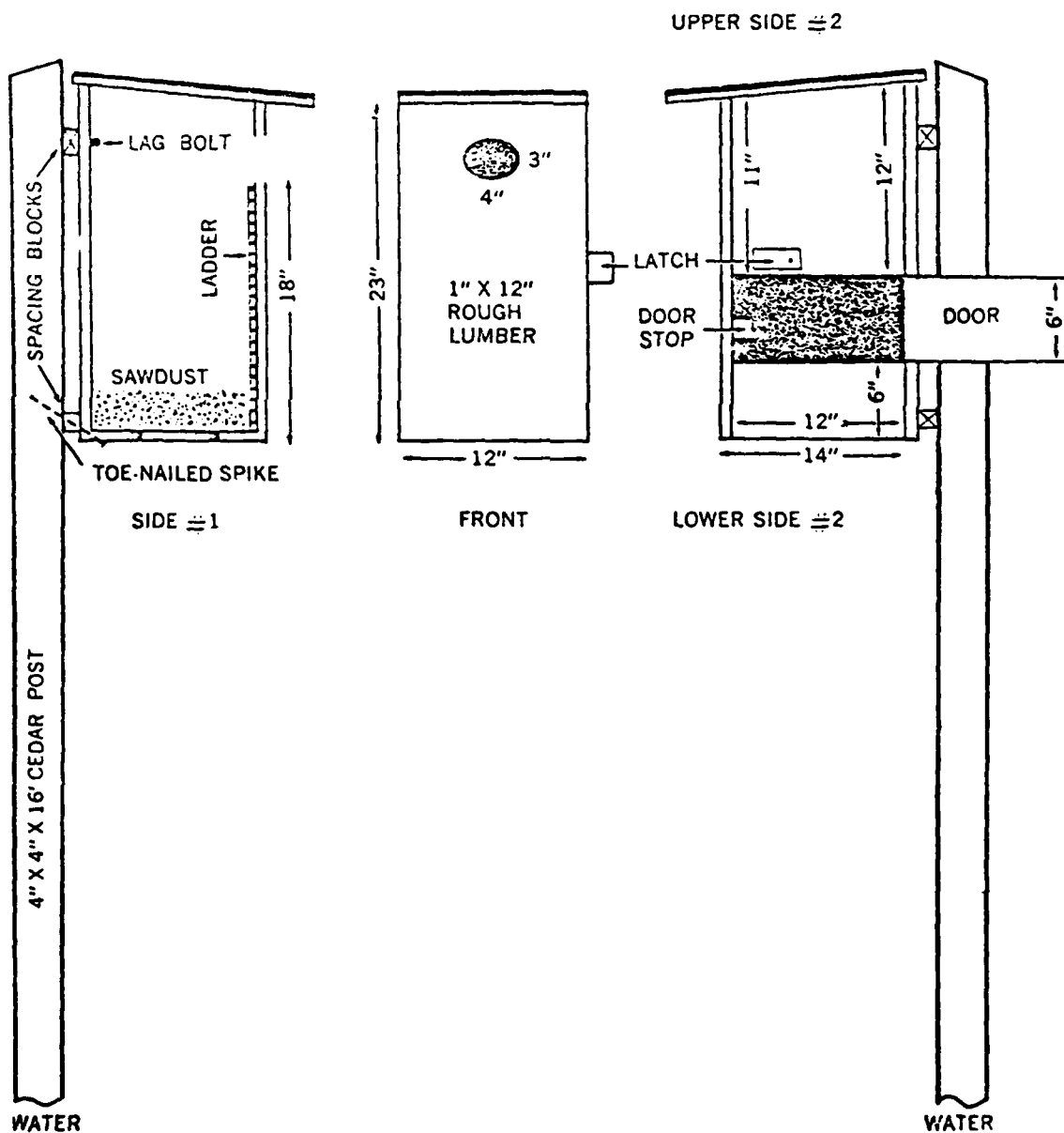
4. Another alternative to minimize contaminant mobility on Barrier Island would be to discourage wildlife feeding areas on the island, but rather to concentrate wildlife feeding in the agricultural units 1-4 as shown on page 134. These units should not contain contaminated sediments or soils and therefore should have very little risk for contaminant mobility.

5. Barrier Island can be managed to minimize mobility of toxic contaminants with available information at present. With appropriate monitoring, the management of the island can be ensured. As stated in the EIS, the quoted sentence on page 134 could imply our concerns. However, we would hope as the project develops that the concerns raised are not overlooked.

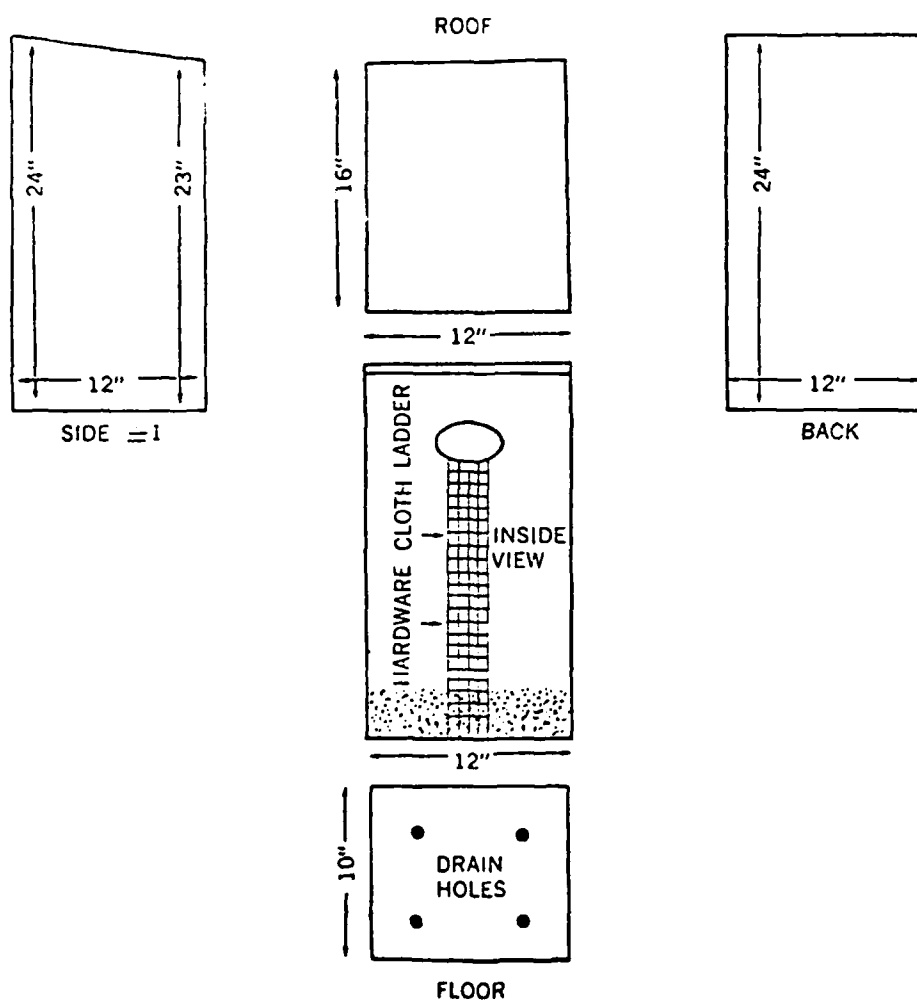
APPENDIX D: U. S. FISH AND WILDLIFE SERVICE GUIDELINES FOR
BUILDING WOOD DUCK NESTING BOXES AND PREDATOR GUARDS

Nesting Box

This nesting box is cheap to build, easy to maintain, and, properly safe-guarded, inaccessible to such nest predators as raccoons, snakes, and squirrels.



The box should be constructed of unplanned cedar, cypress, or other weather-resistant lumber. It should NOT be painted, stained, or creosoted. As the diagram indicates, the entrance should be oval-shaped with the broadest distance horizontal. On the inside front of the box, beneath the hole, a strip of screen or hardware cloth should be tacked to provide the ducklings a means of escaping the box.



Materials

- Nails 25—8 or 10-penny, zinc-coated.
- Spike.....1—4+ inch.
- Lag bolt 1— $\frac{1}{4}$ -inch, 6 inches long.
- Hinge 1—3-inch cabinet + screws.
- Hardware Cloth 18-inch strip cut at least 3 inches wide. (All sharp ends should be bent under.)
- Post 1, 4" X 4", 16 feet long. (Should be cypress, cedar, or a preservative-treated wood.)
- Plus Enough sawdust, wood-chips, or crumbled rotten wood to form a 3-inch nest base in each box.

Use rust-proof screws or nail that are long enough to hold securely despite rough handling and weathering.

Bore four $\frac{1}{4}$ -inch drainage holes through the floor.

Tack a strip of $\frac{1}{4}$ -inch mesh hardware cloth cut about 18" X 3" from the bottom of the box to the hole. This is necessary in order for the ducklings to be able to climb out the nest.

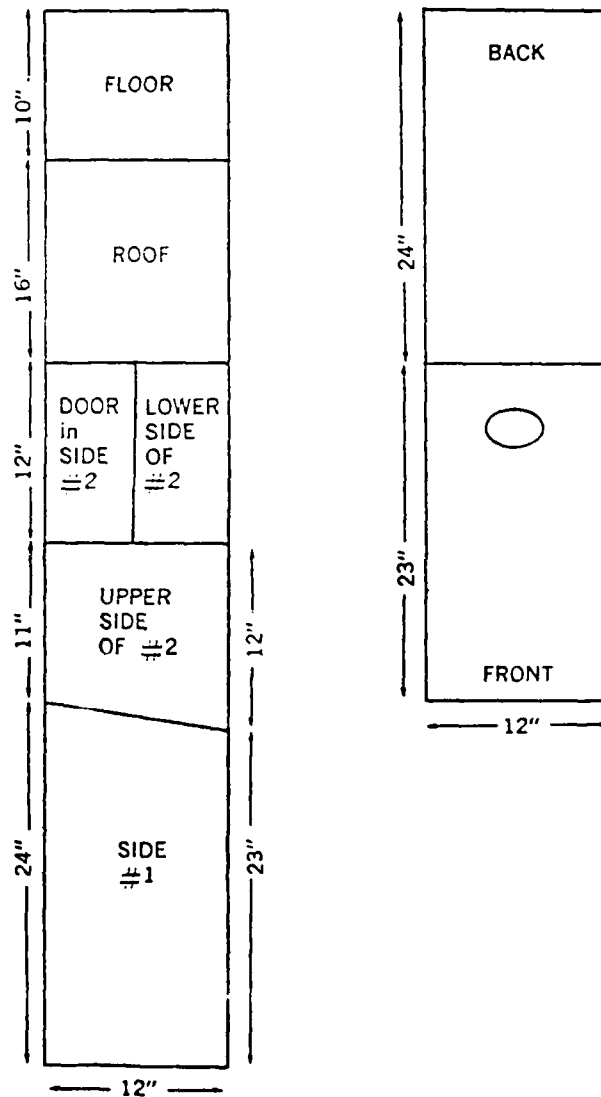
Spray the inside of the box with lysol or other disinfectant prior to the nesting season to discourage wasp and bees from moving in.

Wood ducks will nest in close proximity, but for the best results, the boxes should be grouped in clusters of half-a-dozen or so spaced so that each is no less than 50 feet from any other.

Each nest box must be cleaned and replenished with sawdust or wood chips each January.

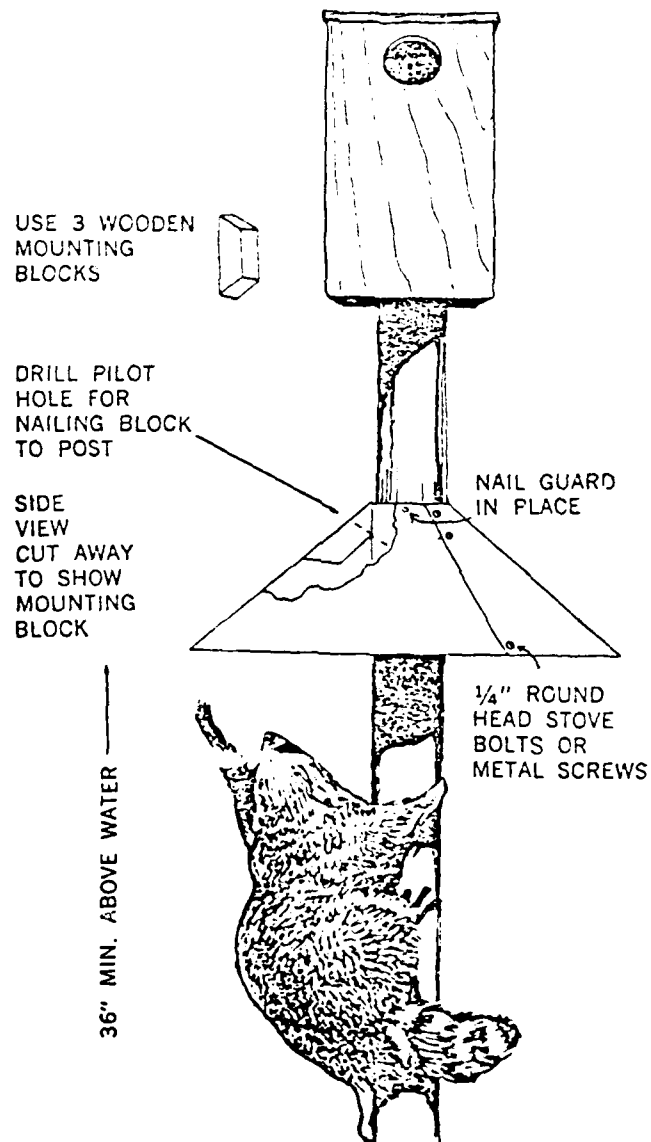
Cutting layout

10 LINEAR FEET OF 1' X 12" ROUGH LUMBER



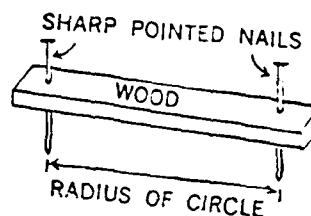
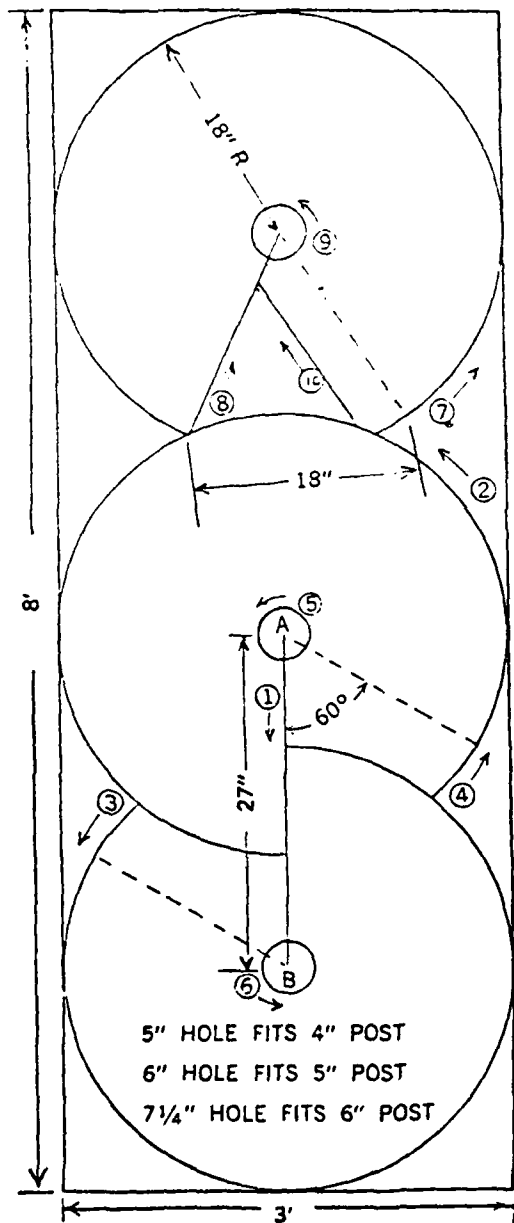
Predator Guard

Installation of cone-shaped sheet-metal guard



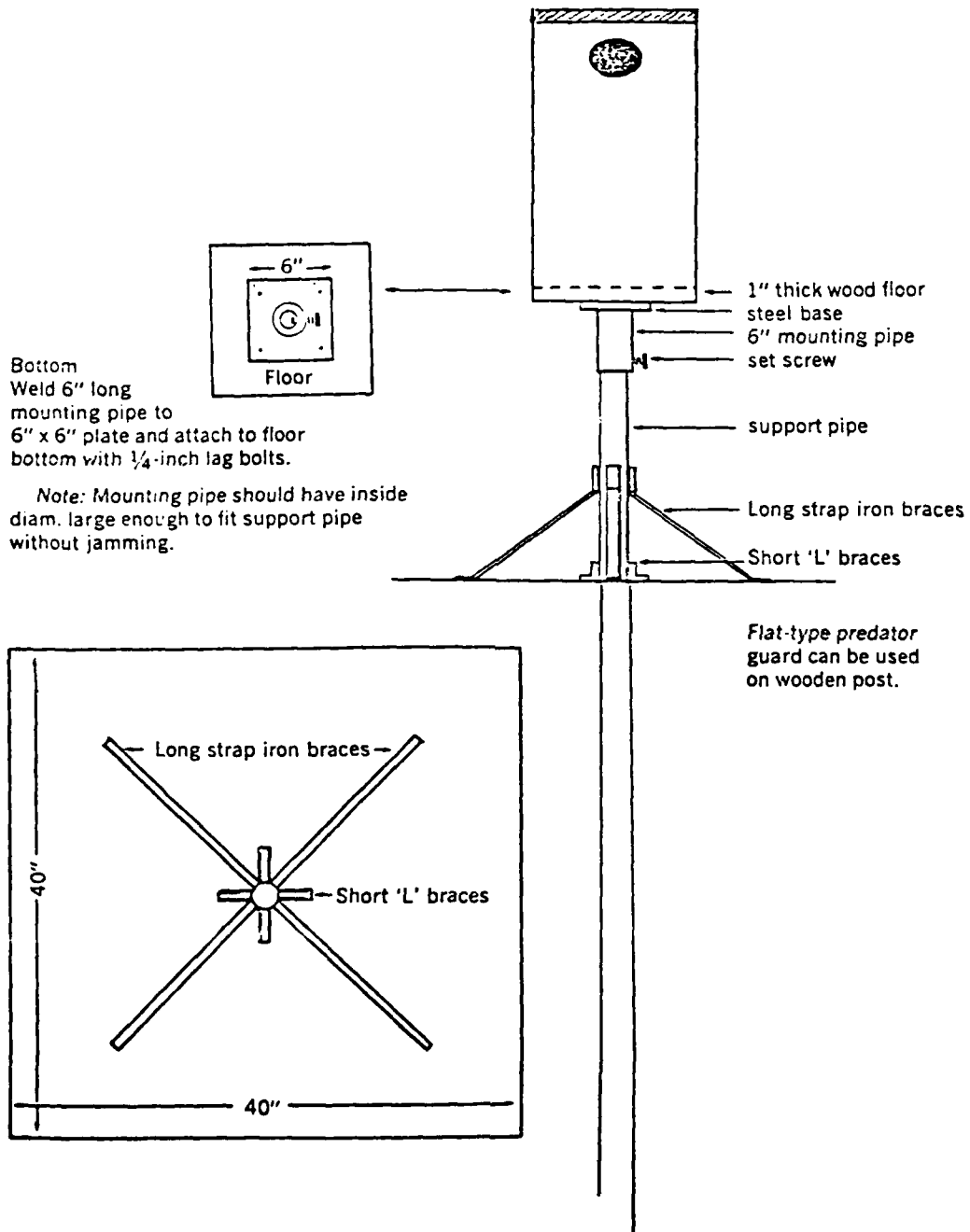
Cutting layout

Layout for cutting 3 predator guards from a 3' x 8' sheet of 26-gauge galvanized metal. When installing the guard, overlap the cut edge to the dotted line. To facilitate cutting (on solid lines only), follow the sequence of numbers. Make circular cuts in counterclockwise direction. To make initial cut on line A-B, make a slot at A with a cold chisel. Use tinsnips and wear leather gloves.



HOME MADE COMPASS
FOR SCRIBING METAL

Variations in Mounting and Predator Guard



In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Habitat development at eight Corps of Engineers sites : feasibility and assessment / Mary C. Landin, Editor (Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. ; available from NTIS, 1982.
245 p. in various pagings ; ill. ; 27 cm. --
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Cover title.
"October 1982."
Final report.
"Prepared for Office, Chief of Engineers, U.S. Army under Dredging Operations Technical Support Program."
At head of title: Dredging Operations Technical Support.
Bibliography: p. 198-207.

1. Dredging spoil. 2. Estuarine biology.
3. Wildlife habitat improvement. I. Landin, Mary C.

Habitat development at eight Corps of Engineers : ... 1982.
(Card 2)

II. United States. Army. Corps of Engineers. Office of the Chief of Engineers. III. Dredging Operations Technical Support Program. IV. U.S. Army Engineer Waterways Experiment Station. Environmental Laboratory. V. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station) ; D-82-1.
TA7.W34m no.D-82-1

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